Appendix 5

Memo, Flow measurement of the Niobrara River within Agate Fossil Beds National Monument, August 8, 2002

Description of a seepage study on the Niobrara River through the park to attempt to locate reaches of gain or loss of streamflow.

United States Department of the Interior

NATIONAL PARK SERVICE

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IN REPLY REFER TO:

N16C (AGFO)

August 8, 2002

Memorandum

To: File

From: Kimberly Howard, AGFO Biological Technician Kimberly M Howard

Subject: Flow Measurement of the Niobrara River within Agate Fossil Beds National Monument.

Summary: Flow measurements of the Niobrara River within the park boundaries were taken July 25, 26 and 29 and August 7, 2002, by Kim Howard, Lil Morava (AGFO VUA) and Nick Schonek (AGFO VIP.) The purpose of this was to establish locations of springs and seeps as well as become familiar with the flow patterns of this reach of the Niobrara River. The flow was measured with a sag tape method starting from the left bank. A Global Water Meter was used to measure velocity in decameters per second. All other measurements were made in meters. For a complete procedure see page 2.

Frequency of Measure: The first flow measurement was taken at the staff gauge near the Agate Springs Ranch headquarters bridge and is referred to as "ranch" in the spreadsheets. Flows were then taken after a seep or spring or every ¼ mile straight distance. See the attached map for distribution. Each location was GPSed and assigned a sequential number (F2, F3, F4 .....). If the flow was near another park feature, this was noted on the data sheet but not in the GPS.

Data: The data were entered into Excel. Discharge was calculated for each cell (depth X cell width X velocity) giving cubic decameters per second. These were added up for each flow to give the total per location and is saved in the worksheet labeled "Raw Data." A second worksheet was created, labeled "Summary of Data," which summarizes the data on to one page and provides additional information. The fields for the summary sheet are as follows:

Site: name of site in GPS and ArcView layer
Date: Date the flow was collected, times of flow collection are in the ArcView layer.
m2/sec: The discharge was converted to cubic meters per second (cms) from the totals
cfs: cms were converted to cubic feet per second (cfs) using the correction factor of one cubic meter/second = 35.314666 cubic foot/second.
Stage: Stage reading at time of flow, derived from gauge graph at Agate Springs Ranch
Corr Stage: Used the correction factor of +0.13 cfs as recommended by Dan Hitch of the USGS Nebraska District at North Platte, who measured Niobrara River flow and adjusted the gauge on 8/7/02.
Flow Curve: Flow derived from rating curve using the corrected stage, curve develop 10-01-1986.
Change from Previous:
Cfs: discharge in cfs minus previous discharge in cfs
Stage: Change in stage readings from previous discharge location
Reason: known reason for significant change.

Comments: The last rating table for the gauge was developed in 1986, and the last published record for the gauge was in 1991. Since then the paper has been changed by park staff and a record of stage kept at the park office.

Procedure:

1. Measure distance from left to right bank, leave the tape staked across the channel, Align the 1 meter mark with the left wetter edge.

2. Find distance to right wetted edge, remember to subtract 1 m from tape distance.
3. Divide the distance between wetted edge by ten, so if the wetter edge was 2 meters, one cell would be 0.2 m.
4. Divide the unit in halve to find the middle of the cell, so 0.2 m would be 0.1 m, this will be your first measuring point.
5. Find depth and record at the first point then multiply depth by 0.60 and take flow at that depth. So if the depth was 0.5 m, flow would be taken at a depth of 0.3 m. Record average flow after 40 seconds.
6. Repeat depth and flow in the middle of each cell, in the example used above this would mean add 0.2m to 0.1m to take the measurement at 0.3 m. you should have a total of 10 measurements.

Finding discharge from measurements
The flow measurements can be should be entered into a spreadsheet and calculations done using functions. I will set up the spreadsheet, but this is to give an idea of the calculation made.
Formulas: Discharge (Q) = Area (A) X Velocity (V)
$Q = m^3$ / second, $A = m^2$, V = m / second
A = cell width times water depth, V = reading of flow meter.

Conclusions
The 2002 flow measurements taken indicate not much water is gained by the Niobrara River through the park. Only two springs were positively identified and several seep areas. Measurements were taken in a drought year, in the middle of summer with irrigation in progress, which all affect the measurements greatly. If flows were taken in the fall or spring, with no irrigation in progress upstream, measurements would be more valuable and comparable. Six weeks after the survey, I noted several possible springs and noticed more water in ponds that are groundwater fed, indicating there are probably more springs but they were not active at the time of survey.

To further evaluate flow in the river, several suggestion have been discussed. The gauging station at the ranch needs to have a new rating table developed for converting stage into flow. It might also be possible to use the culvert at the ranch bridge as a weir to develop a rating curve for water height compared to flow. The web site http://www.albemarle.org/engineer/personnel/channelflowhelp.html provides information in this topic. And finally, if further measurements flow measurements are taken using the sag tape method (the one described in the main text of this memo), the Dan Hitch of the USGS recommends using 20 cells instead of ten. With higher flows this will be easier, as the river will be wider.

Attachments:
Summary of Niobrara Flow Data
Flow Data Collection Points Map

AGFO

Summary of Niobrara Flow Data

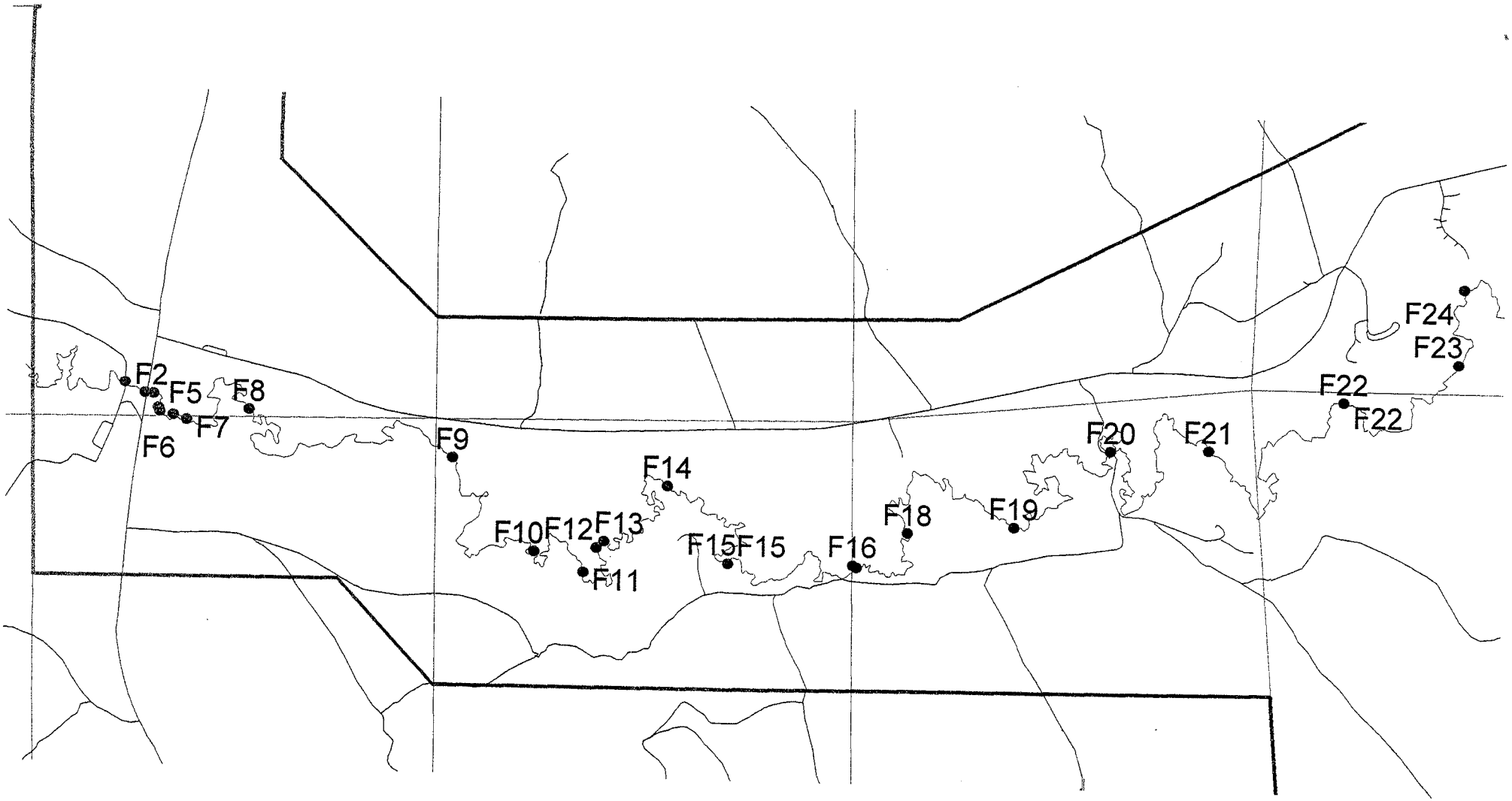
8/26/02

Site	Date	probe	m2/sec	cfs	Stage	Corr Stage	Flow Curve	Change from Prev		reason
								in cfs	stage	
Ranch	7/25/02	1.65	0.16	5.82	2.78	2.91	6.35			AM
Ranch	7/25/02	1.24	0.12	4.36	2.68	2.81	5.14	0	0	PM
Ranch	7/17/02	1.01	0.10	3.58	2.38	2.51	2.23	0	0	
Ranch	8/6/02	1.15	0.11	4.04	2.54	2.67	3.65	0	0	
Spring1	7/25/02	0.03	0.00	0.11	2.72	2.85	5.61	0	0	
F2	7/25/02	1.64	0.16	5.80	2.70	2.83	5.37	-0.02	-0.08	irrigation
F3	7/25/02	1.61	0.16	5.69	2.66	2.79	4.91	-0.11	-0.04	irrigation
F4	7/25/02	1.54	0.15	5.45	2.65	2.78	4.80	-0.23	-0.01	irrigation
F5	7/25/02	1.61	0.16	5.68	2.65	2.78	4.80	0.22	0.00	
F6	7/25/02	1.70	0.17	5.99	2.65	2.78	4.80	0.32	0.00	
F7	7/25/02	1.51	0.15	5.34	2.65	2.78	4.80	-0.65	0.00	
F8	7/25/02	1.29	0.13	4.54	2.65	2.78	4.80	-0.81	0.00	
F9	7/25/02	1.65	0.17	5.83	2.65	2.78	4.80	1.29	0.00	silty bottom
F10	7/25/02	1.60	0.16	5.66	2.65	2.78	4.80	-0.17	0.00	
F10	7/26/02	1.93	0.19	6.80	2.79	2.92	6.47	1.14	0.14	new day
F11	7/26/02	2.04	0.20	7.21	2.97	3.10	8.93	0.41	0.18	
F12	7/26/02	2.31	0.23	8.16	2.74	2.87	5.85	0.95	-0.23	
F13	7/26/02	1.57	0.16	5.56	2.73	2.86	5.73	-2.61	-0.01	
F14	7/27/02	1.76	0.18	6.21	2.73	2.86	5.73	0.65	0.00	
F15	7/27/02	1.86	0.19	6.57	2.72	2.85	5.61	0.36	-0.01	
F15	7/29/02	1.49	0.15	5.26	2.64	2.77	4.69	-1.31	-0.08	new day
F16	7/29/02	1.56	0.16	5.52	2.63	2.76	4.58	0.25	-0.01	
F17	7/29/02	1.50	0.15	5.30	2.62	2.75	4.47	-0.22	-0.01	
F18	7/29/02	1.43	0.14	5.05	2.61	2.74	4.37	-0.25	-0.01	irrigation
F19	7/29/02	1.62	0.16	5.73	2.61	2.74	4.37	0.68	0.00	
F20	7/29/02	1.39	0.14	4.90	2.60	2.73	4.26	-0.82	-0.01	
F21	7/29/02	1.32	0.13	4.67	2.60	2.73	4.26	-0.24	0.00	
F22	7/29/02	1.44	0.14	5.09	2.60	2.73	4.26	0.42	0.00	
F22	8/7/02	1.62	0.16	5.65	2.53	2.66	3.55	0.57	-0.07	new day
F23	8/7/02	1.32	0.13	4.66	2.52	2.65	3.45	-0.99	-0.01	
F24	8/7/02	1.21	0.12	4.27	2.51	2.64	3.36	-0.39	-0.01	irrigation

1 cubic meter/second
= 35.314666 cubic foot/second

Prepared by Kim Howard, AGFO BioTech

Flow Data Collection Points



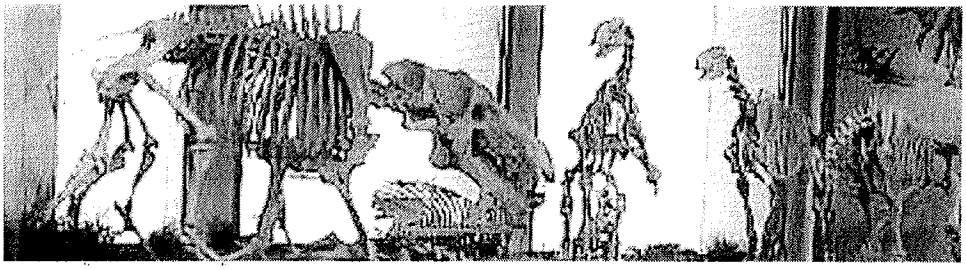
Niobrara River
Flow locations
Roads
Boundary Line
Section Lines

Flow collected by Kim Howard, Lil Morava and Nick Schonek, July25 - August 7, 2002

Map created by Kim Howard, 8/8/02

Appendix 6

Description of "Geologic Formations" and "Rivers and Streams" from the monument's website; "www.nps.gov/agfo".



Geologic Formations

Agate Fossil Beds National Monument is a small park in the northwest corner of Nebraska, with only 2,700 acres of federally managed land included in the 3050 acres within the park boundary. The park takes its name from thin lenses of agate (White River Silicate Group) in the area, which range in color from amber to light gray. Miocene-age rocks are exposed in the park in the bluffs above the Niobrara River wetlands and contain an excellent fossil record.

The Rocky Mountains were uplifted in many pulses of deformation between 70 to 40 million years ago. Sediments from the uplifting mountains were initially deposited near the mountains and then later transported by rivers eastward onto what eventually became the Great Plains. This river-borne silt was accompanied by wind-borne volcanic ash from eastern Nevada and western Utah, and the fine grained ash rich sediments were deposited in vast sheets called the White River beds. The earliest documented bedrock at Agate dates to the Oligocene era, 34 million years ago, but most of Agate's Oligocene deposits are well buried beneath later Miocene deposits. Oligocene-era beds are well exposed at Badlands National Park, 130 miles northeast of Agate.

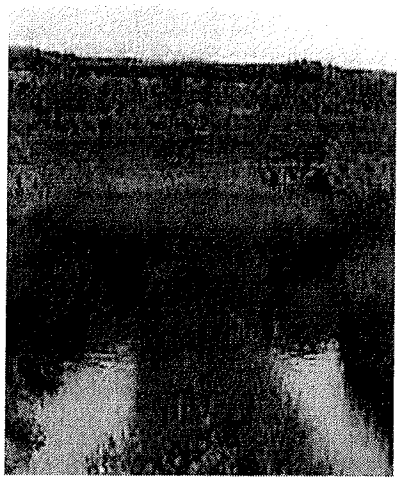
During the early Miocene era, beginning about 25 million years ago, streams in the area that now includes Agate Fossil Beds National Monument shifted and cut down to produce valleys. These valleys were later filled in with sediments as the Great Plains continued to build up or aggrade. Aggradation resulted in the formation of wide savannas during the Miocene, those savannas being dotted with small water holes and the whole landscape populated with herds of animals (e.g., chalicotheres, rhinoceroses, entelodonts, beardogs, land beavers, camels, horses, pocket gophers). Ongoing research is documenting the grass species present on the ancient savanna. A major drought occurred in the Agate area during the Early Miocene. It is believed that when many of the drought-stricken and exhausted animals came to the remaining water holes in an effort to survive, the animals collapsed and died in and around the water. As the muddy water dried, the fossil beds were formed. Agate's older fossil layer is about 21 million years old and covered by a layer of ash, and its younger bed is 20 million years old. These layers are in what are now called the Harrison and Marsland Formations.

In the last five million years the High Plains have continued to uplift to their current elevation of about 4,400 feet a.m.s.l. and the savannas have changed to the grasslands of today. During the uplifting process rivers and streams have meandered across the plains and eroded the older deposits, forming the bluffs and valleys that we see today.

The modern Niobrara valley at Agate is a complex array of Late Pleistocene and Holocene geomorphology, stratigraphy, and paleosols reflecting significant climate variations over the past 12,000-15,000 years. Current research in the park is providing radiocarbon dates for the middle to late Holocene materials, documenting thousand-year-or less fluctuations between warm and cooler climates and varying amounts of annual moisture.

The agates that give the park its name are found in a thin band along ash deposits just above the Miocene bone beds, and range in color from amber to light gray. This stone is a variety of quartz (silicon dioxide) called chalcedony. Iron, manganese, and/or aluminum inclusions in the original silica deposits give the agate different colors in various locations, and often form dendritic "moss" patterns in the material.

Text and photo by Kimberly Howard, Biological Technician, Agate Fossil Beds National Monument, August 7, 2002. For further information go to www.nps.gov/agfo.



Rivers and Streams

Among the natural communities of plants and animals existing in the high plains ecosystem, none is as lush or rich in animal life as the riparian community. Riparian zones are the lush belts of vegetation found along rivers and wetlands. The Niobrara flows through the four mile length of Agate, meandering and curving to create 11 miles of river bank. These river banks play a vital role in the plant and animal communities as well as the water quality of the river.

The reach of the Niobrara river within the park is unconfined, meaning it meanders or bends throughout a wide flood plain and changes course relatively often. The flood plain of the Niobrara is a quarter-mile wide in places. This creates an interesting landscape of river twists and turns and oxbow ponds and sloughs filled with cattails, irises, reeds and water loving plants and a great environment for a diverse variety of wildlife. Oxbow ponds are the horseshoe shaped ponds that are the result of a very sharp bend being cut off from the river. Along the river banks, reeds and cattails grow tall and hang over the river providing shade to keep the water cool and reduce the amount of evaporation during hot days.

Though the Niobrara River is the only continuously flowing water in the park there are several ephemeral tributaries to the river. Tributaries are streams that run into and contribute water to a river or larger stream. Ephemeral streams are streams that only flow after a major rain event and can be identified by dry channels in depressions between hills. These are the types of areas in which flash floods can occur that cause death and destruction of property. Though the streams rarely flow and do not flow for very long, they are erosive, sometimes carrying large amounts of sediment to the river. Sediment, soil and sand material that is suspended in the flow of the water deposits when flow slows down, when there is less water or when the water is spread over a greater area.

A major source of water for the Niobrara in and around the park is ground water, water that is stored in and released from aquifers and reservoirs. These large, underground reservoirs can be refilled by rainfall if water can infiltrate that far into the ground.

Groundwater naturally comes to the surface through seeps and springs but is also brought up by wells. A spring is place where groundwater flows naturally from the soil or rock formation onto the land surface or into a body of surface water. Seeps are similar but are usually less defined and do not flow as springs do; here they are characterized by creating a marshy area near the river. There is little specific information known about Agate's groundwater but park staff are currently involved in projects to learn more to be able to better manage groundwater use.

The river running through the park creates a special prairie habitat that is not seen in drier areas. The meandering river creates about 200 acres of riparian area which is the greener, wetter areas near a stream where specialized plants grow. Plants such as willows, reeds, sedges and wild licorice thrive in the riparian areas. Willows and other water-loving shrubs and trees provide browse for white-tail deer. The riparian area also provides home for salamanders and frogs that need more moisture than the dry uplands provide. Park staff carefully monitor and manage the riparian area to restore it to its natural condition by controlling non-native plant species such as the Canada thistle. To learn more about these efforts, look at the Canada thistle page.

Quality of water is enhanced by the riparian areas as the two are interdependent. Trees and shrubs shade the water, reducing evaporations and keeping water cooler which is beneficial to aquatic life. Overall, the water quality at Agate is good, having low levels of nitrates and phosphates that are monitored through yearly sampling. Agate also monitors water quality using by observing macroinvertebrates (insects and other arthropods) that live in the water. Macroinvertebrates are sensitive to pollution and extreme flow fluctuation, so a decrease in species diversity can indicate a problem with the water quality. The Niobrara river is not extremely large at Agate, generally only about 2.5 meters (8.25 feet) wide and flows at around eleven cubic feet per second.

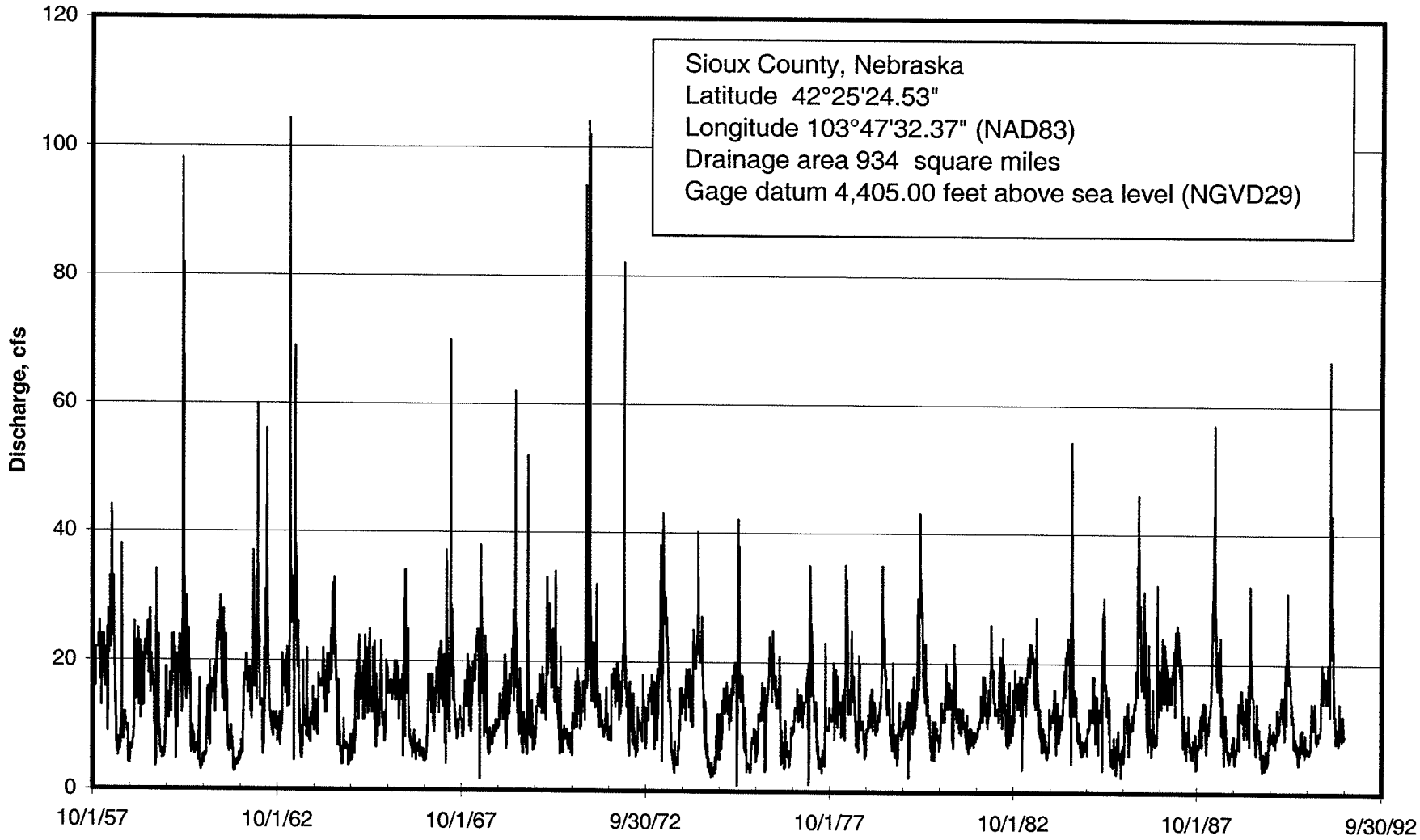
Text and photo by Kimberly Howard, Biological Technician, Agate Fossil Beds National Monument, August 6, 2002. For more information go to www.nps.gov/agfo.

Appendix 7

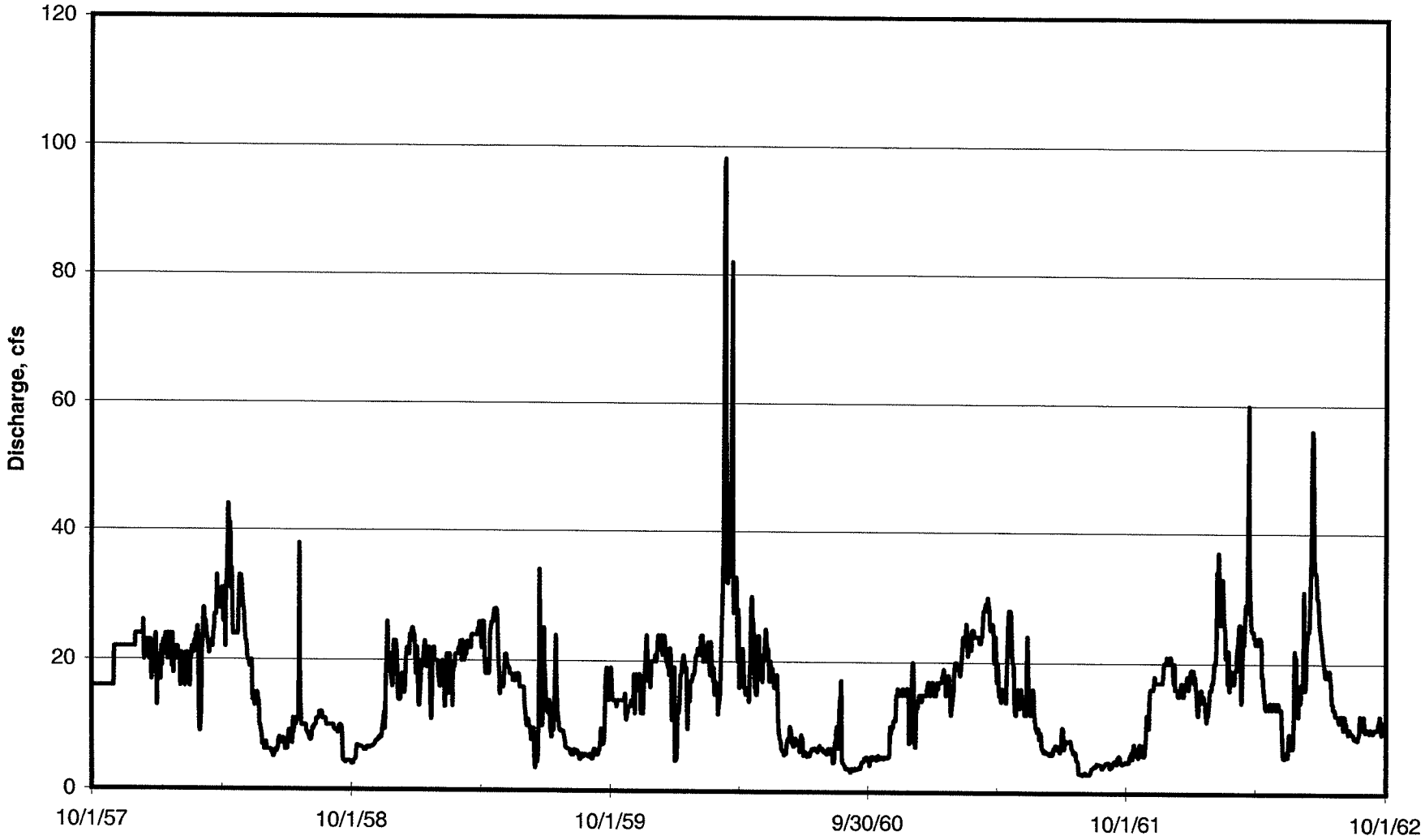
Hydrographs of streamflow in the Niobrara River at Agate, Nebraska; USGS data from 1957-91

Hydrographs from the period that the USGS operated the streamflow gaging station. Data are available from the USGS websited "http://nwis.waterdata.usgs.gov/nwis/"

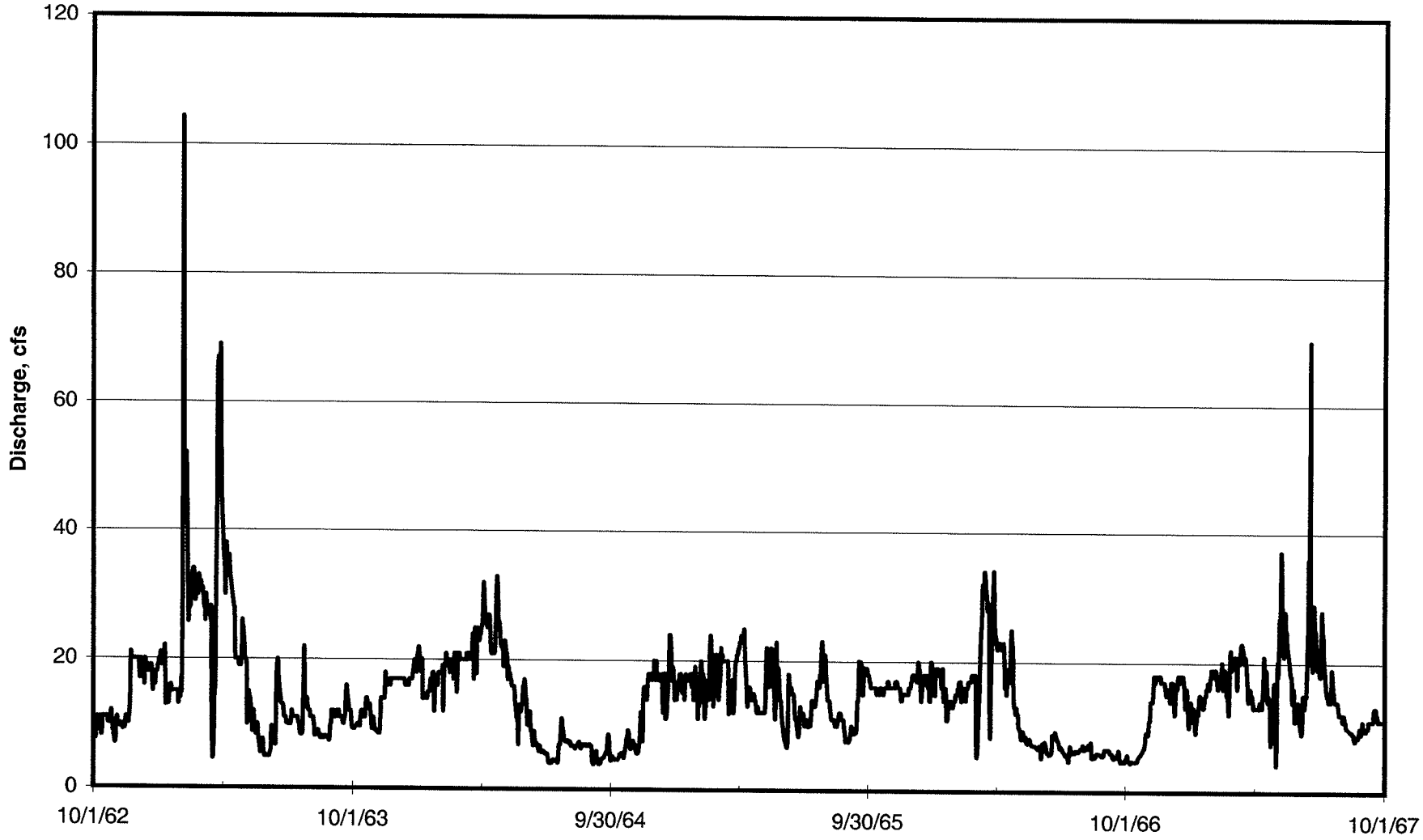
USGS Streamflow Gage 06454100
Niobrara River at Agate, Nebraska



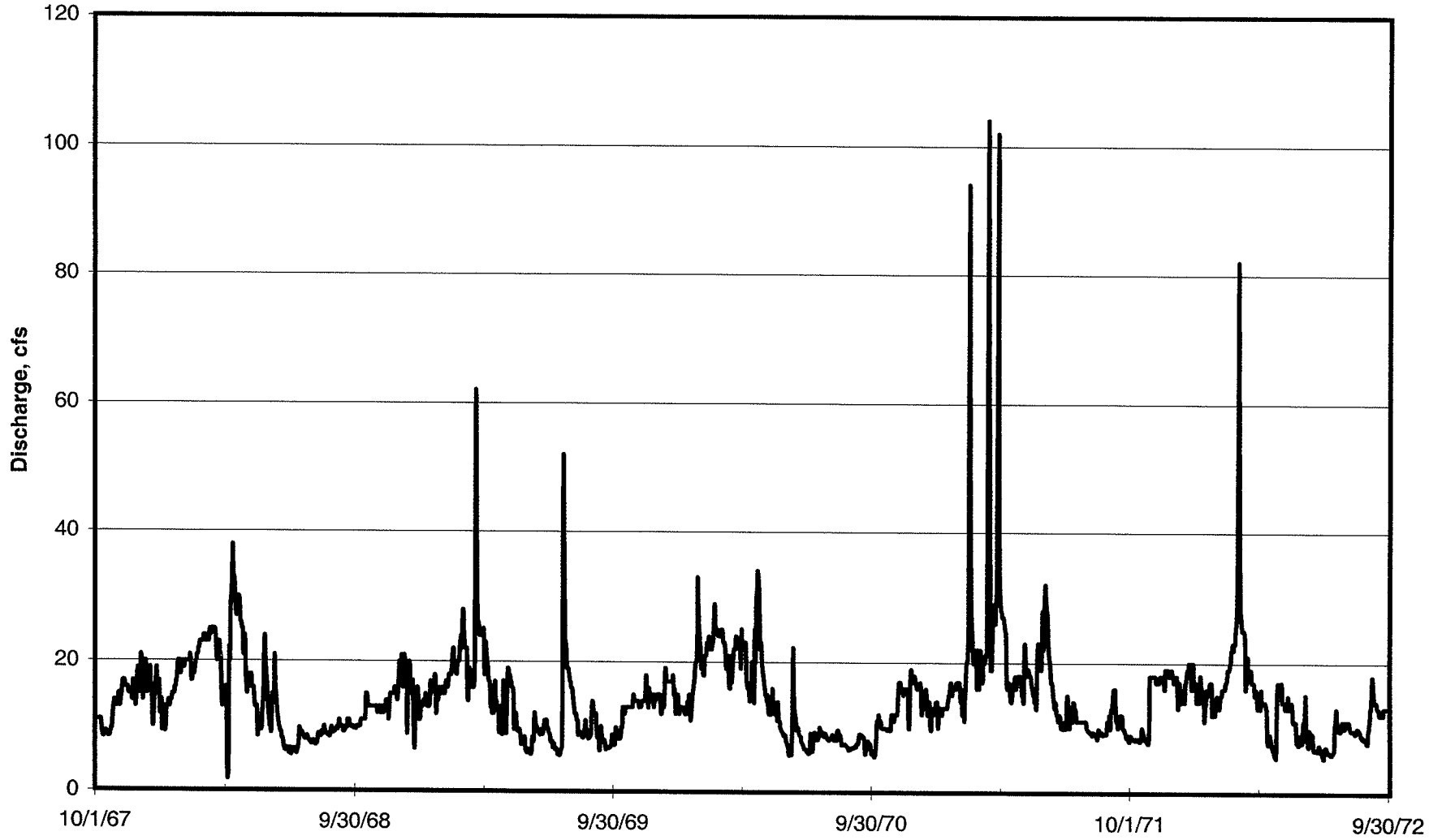
USGS Streamflow Gage 06454100
Niobrara River at Agate, Nebraska



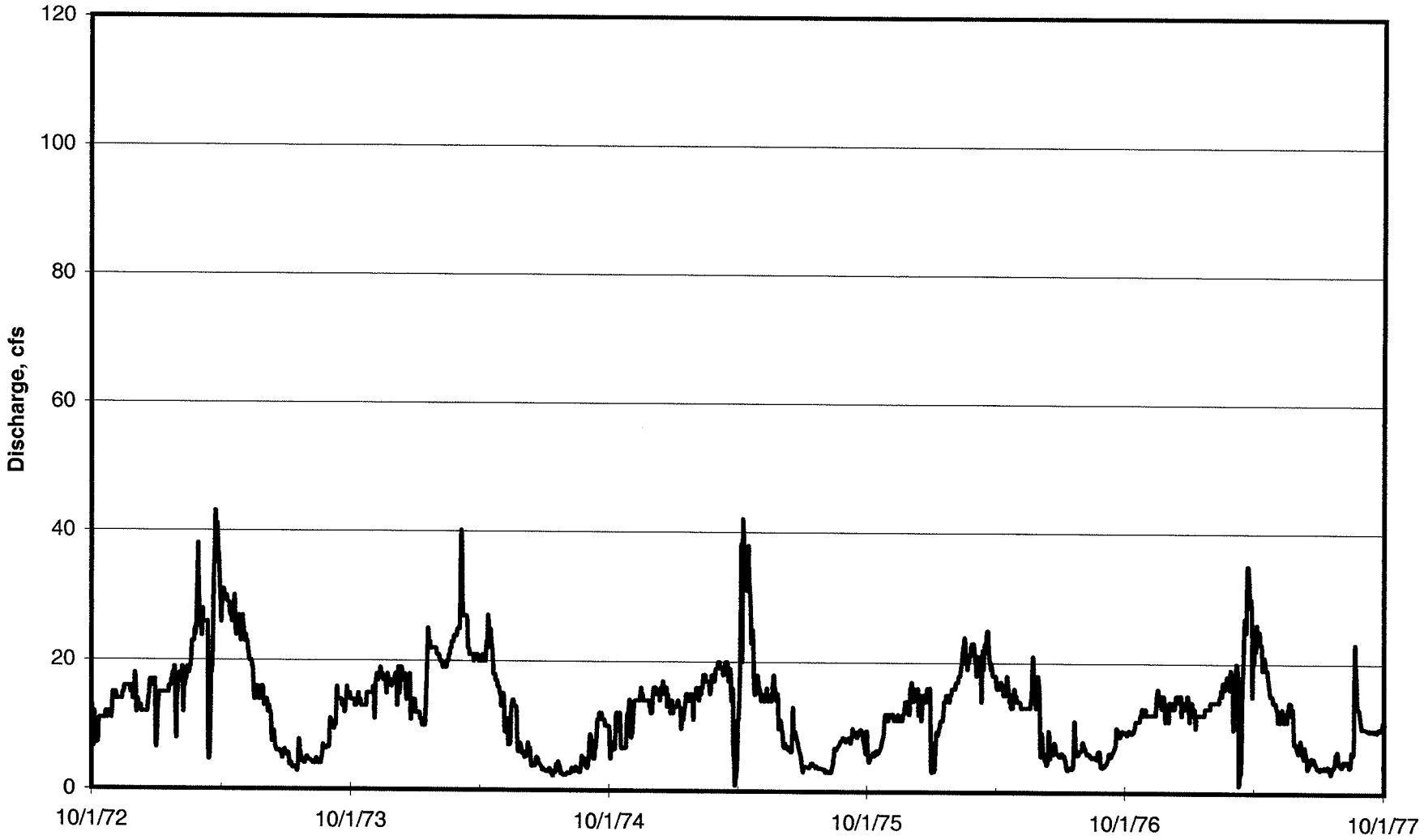
USGS Streamflow Gage 06454100
Niobrara River at Agate, Nebraska



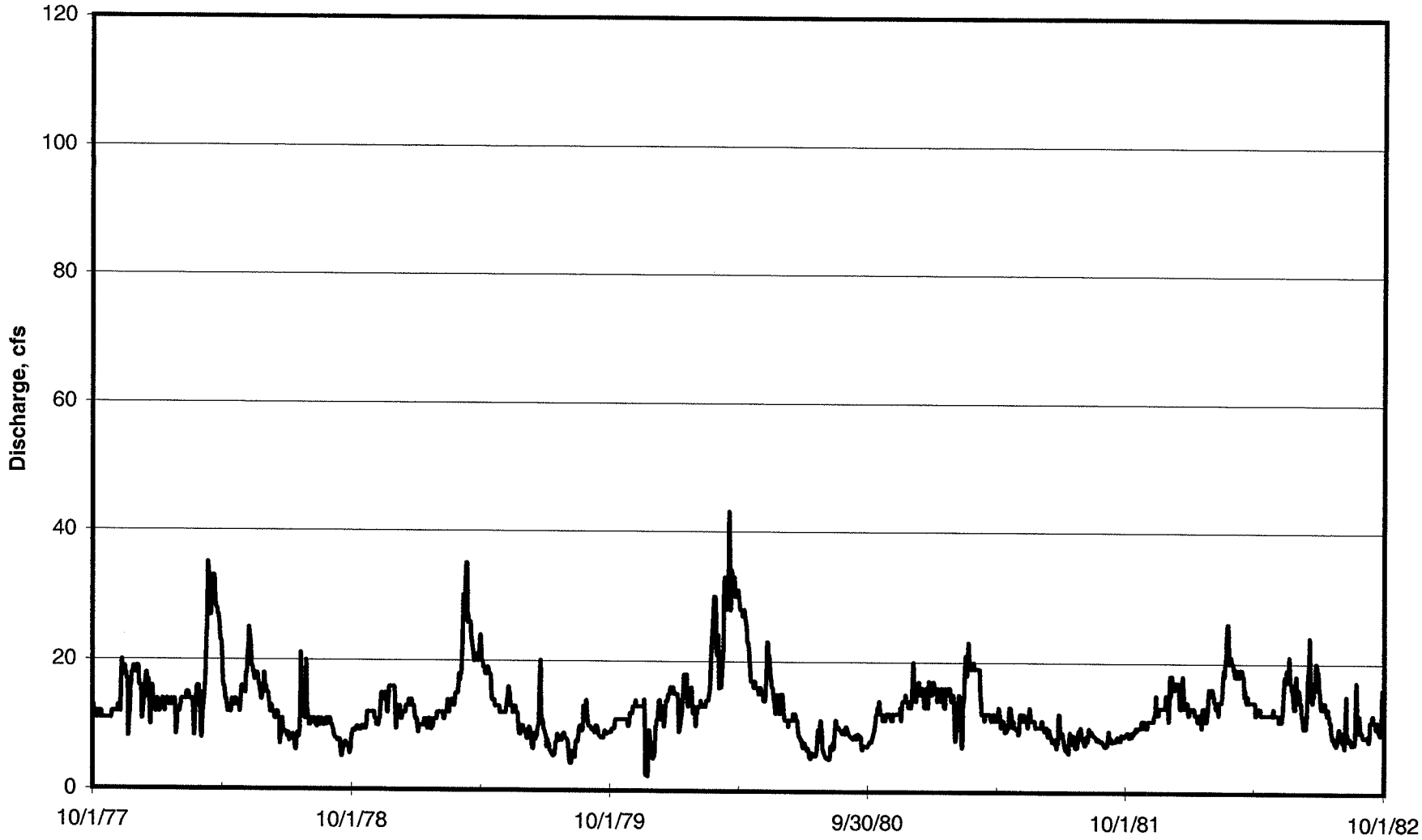
USGS Streamflow Gage 06454100
Niobrara River at Agate, Nebraska



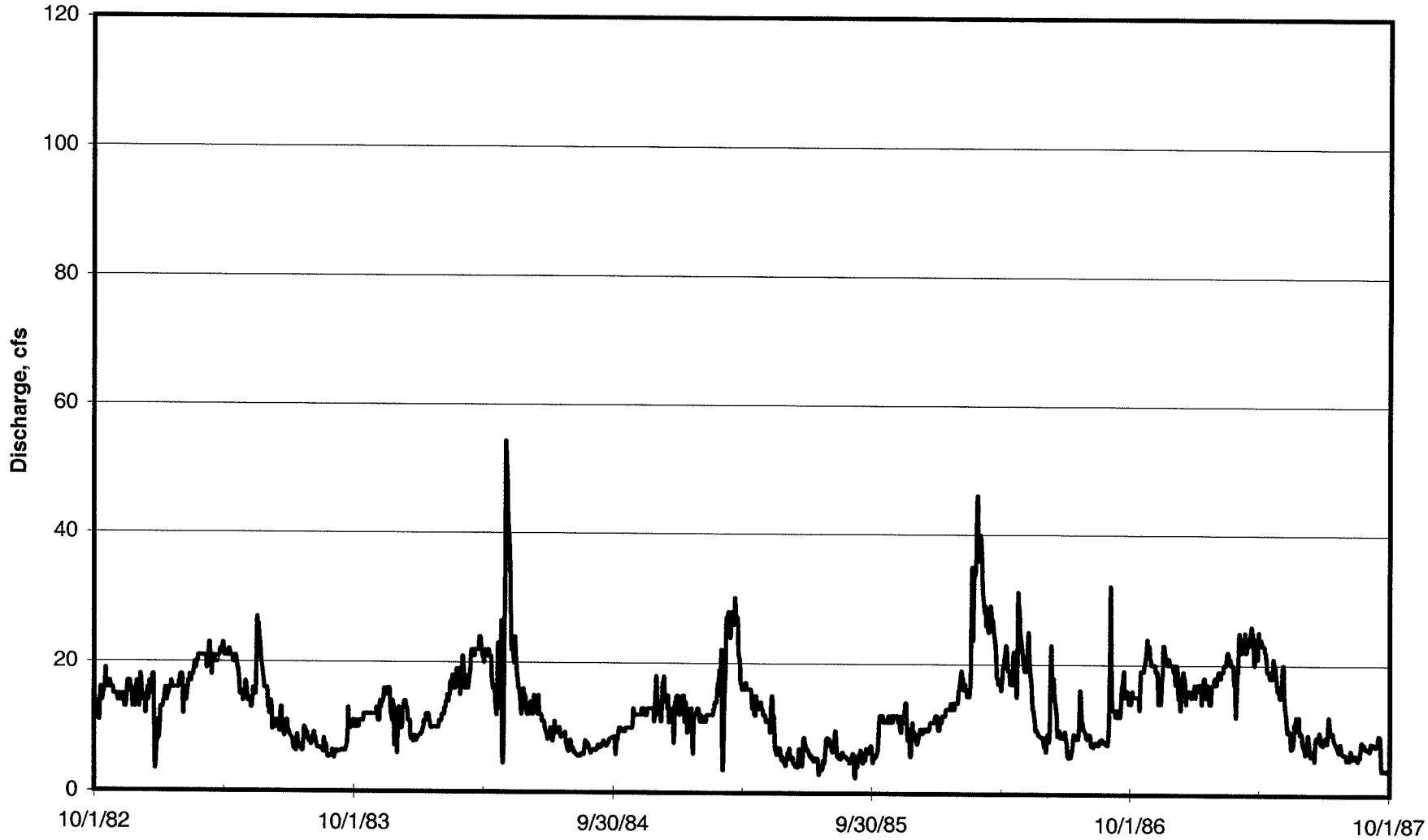
USGS Streamflow Gage 06454100
Niobrara River at Agate, Nebraska



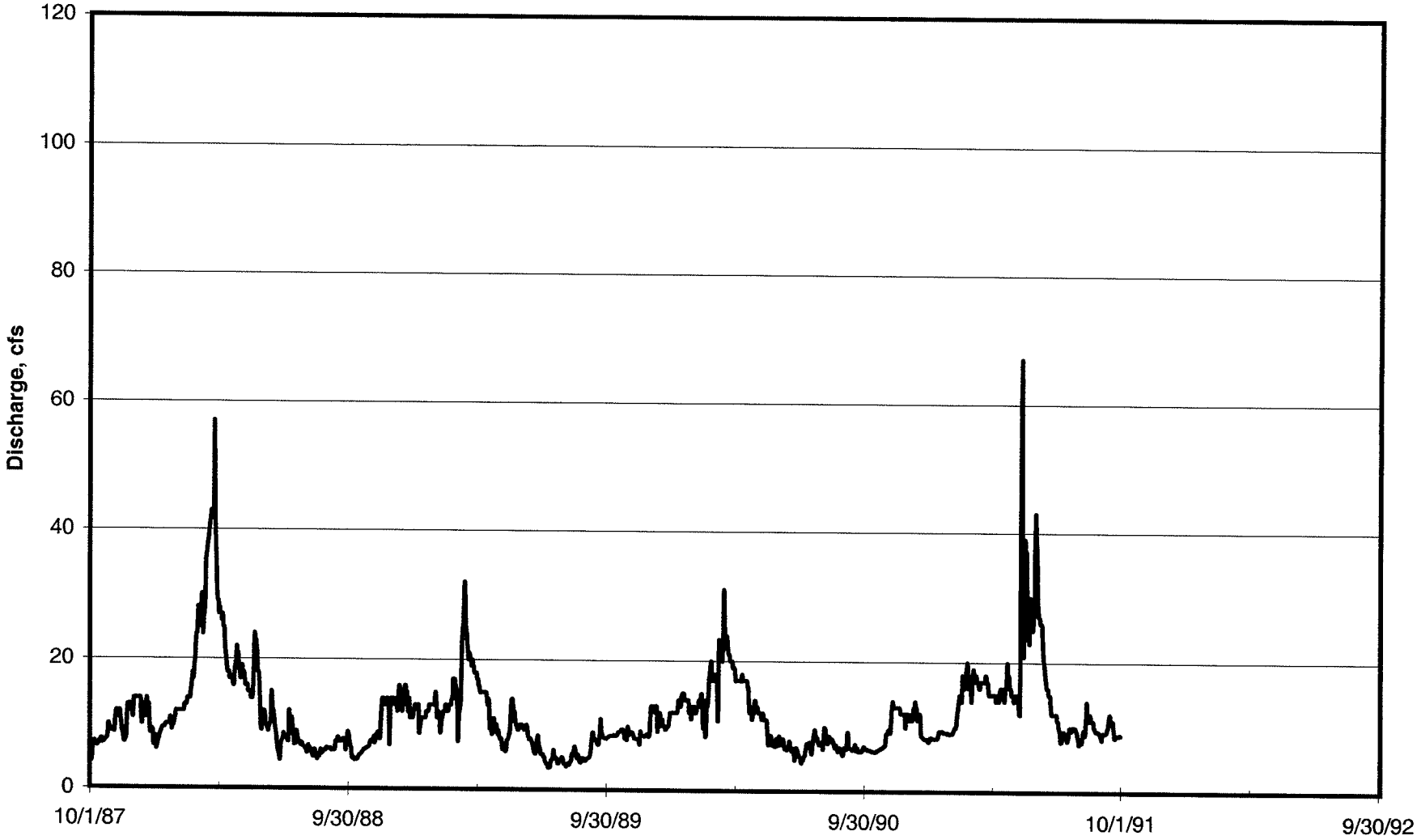
USGS Streamflow Gage 06454100
Niobrara River at Agate, Nebraska



USGS Streamflow Gage 06454100
Niobrara River at Agate, Nebraska



USGS Streamflow Gage 06454100
Niobrara River at Agate, Nebraska



Appendix 8

Streamflow records for the Niobrara River at Agate, Nebraska, 1995-2004

Data and hydrographs of streamflow in the Niobrara River during the period the gaging station was operated by NPS personnel.

Streamflow Records for the Niobrara River at Agate, Nebraska. 1995-2004 Station 06454100

August 2004

Prepared by:
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Water Resources Division
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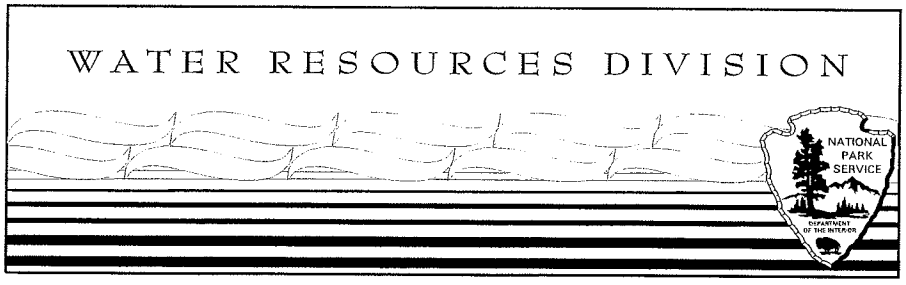
(970)-225-3515



National Park Service - Department of the Interior
Fort Collins - Denver - Washington

The USGS operated a streamflow gaging station on the Niobrara River just upstream of the Highway 29 bridge from 1957-91 (Station Number 06454100). Data for the period when USGS operated the gaging station are available from http://nwis.waterdata.usgs.gov/ne/nwis/discharge. Select the box for "site number" and enter "06454100". This will provide access to the historical data collected by USGS from 1957-91.

National Park Service staff at Agate Fossil Beds National Monument have operated the chart recorder at the site since 1995. The record since 1995 is not continuous because there were many times when the recorder was not functioning properly.

The charts from the recorder for the period from 1995-2004 were analyzed and average daily streamflow values were computed for periods when the chart recorder was operating. Charts were analyzed to determine the average stage of the stream for a particular day. The values for date and stage were entered in an Excel spreadsheet. The stage data were converted to average daily streamflow by applying a regression equation that was developed from the rating curve for the site. The rating curve and regression equation are included in this report. The data were then put in tabular format by water year, similar to the standard USGS format for publishing hydrographic data. These tables and a hydrograph for each year are included in this report.

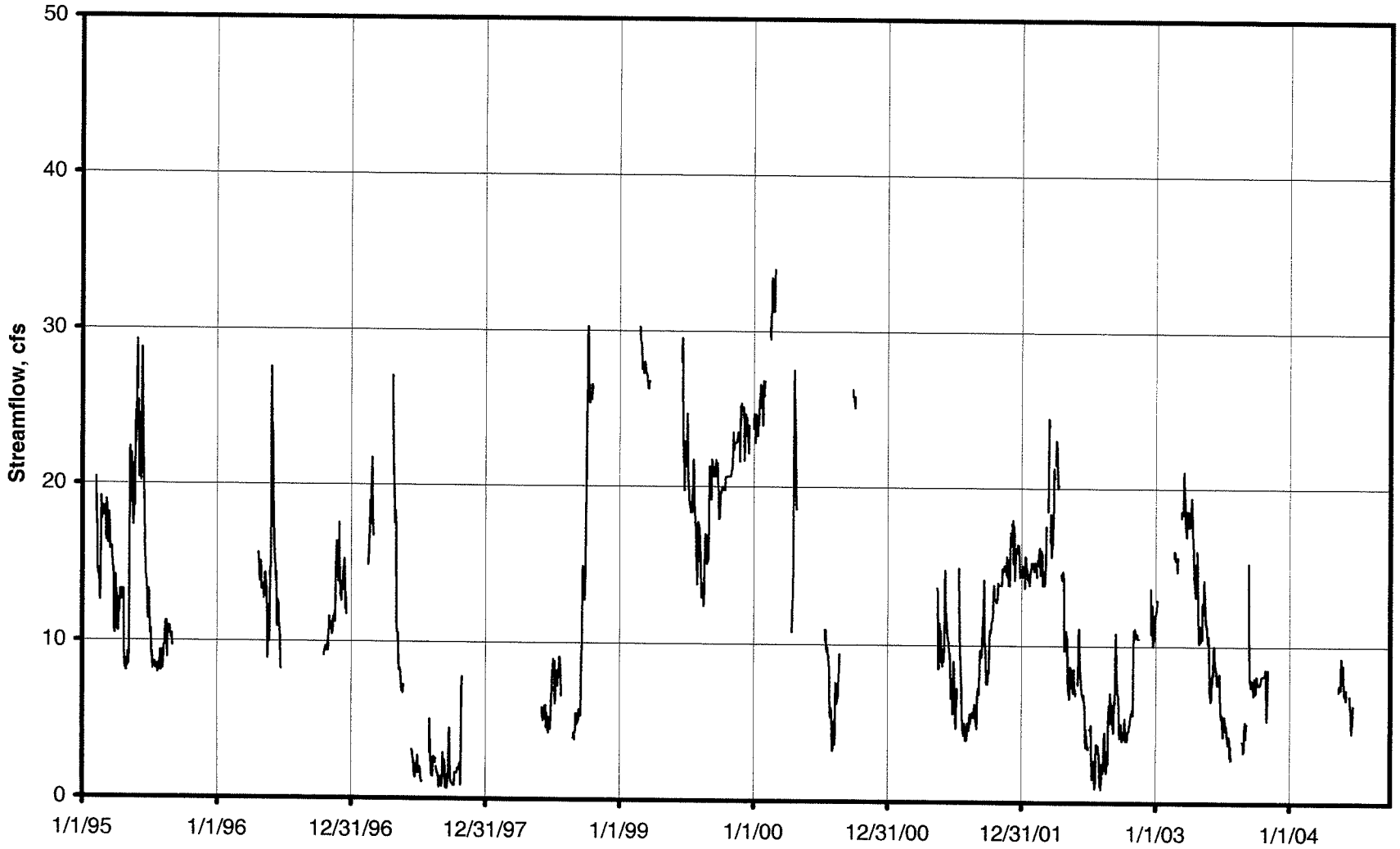
In FY-03, the USGS was contracted to conduct streamflow gaging at this site to evaluate the stage-discharge rating curve for the site. USGS also conducted repair and maintenance of the chart recorder and associated equipment to make certain that it was in good operating condition. Data collected in 2002-03 are shown on a figure in this report along with the rating curve that was used prior to 1991. The data from 2003-03 show that the rating curve is still a fairly reliable tool for converting stage (water level) in the stream to flow rates.

Nebraska DNR is interested in operating a gaging station at this site to assist in their administration of water rights on the Niobrara River. DNR is willing to operate the gaging station and publish the data in their annual "Hydrographer's Report" if NPS would provide funding for the initial purchase of digital recording equipment for the site. The digital recording equipment has been purchased and is in storage at the park. It will be installed after agreements for operation of the gaging station have been negotiated between the NPS, Nebraska DNR, and the landowner.

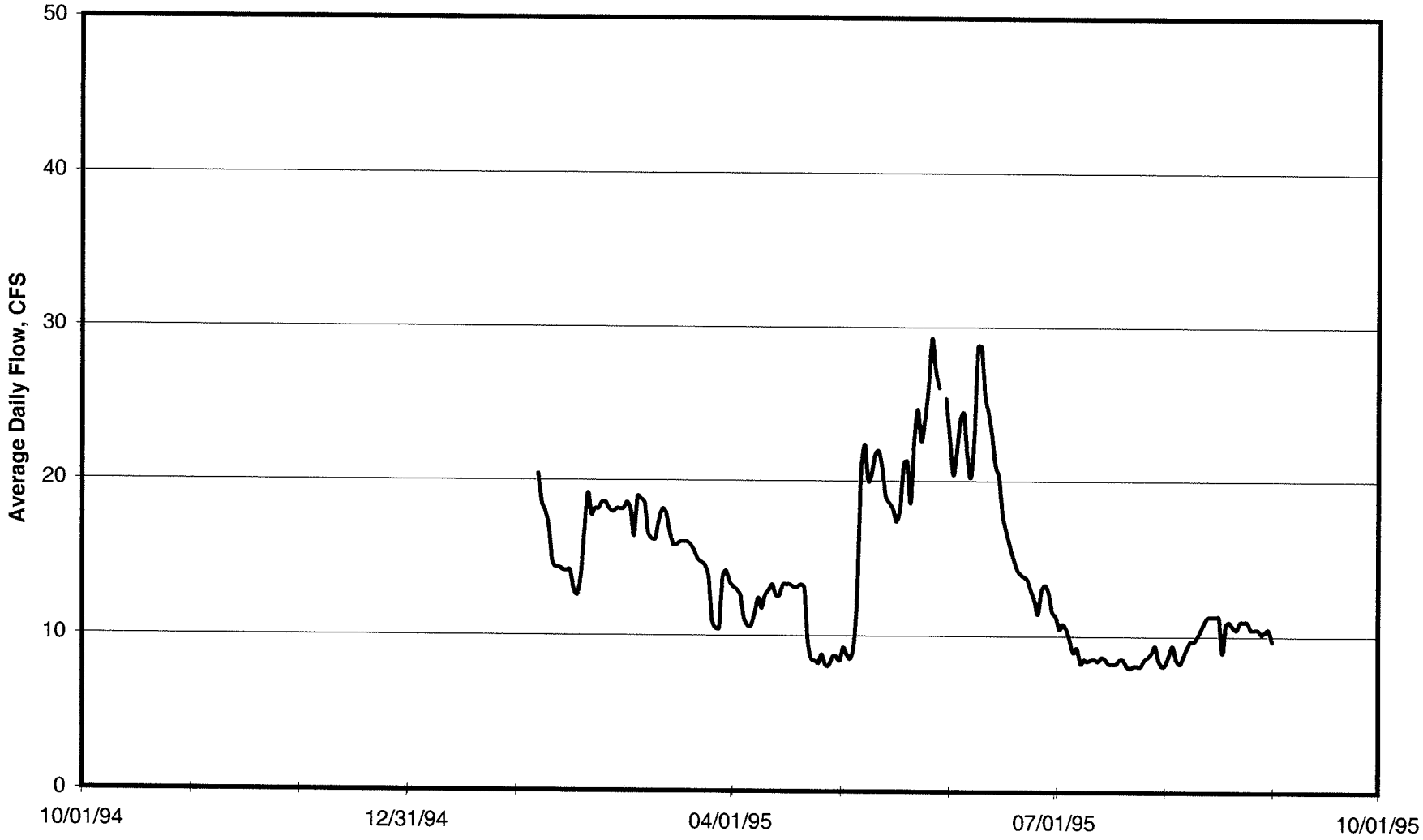
The data analysis and preparation of this report was by Larry Martin, NPS-Water Resources Division, Ft. Collins, CO. Lil Morava at Agate Fossil Beds operated the chart recorder and collected the field data. Dan Hitch, USGS, made the streamflow measurements in 2002-03.

Hydrographs

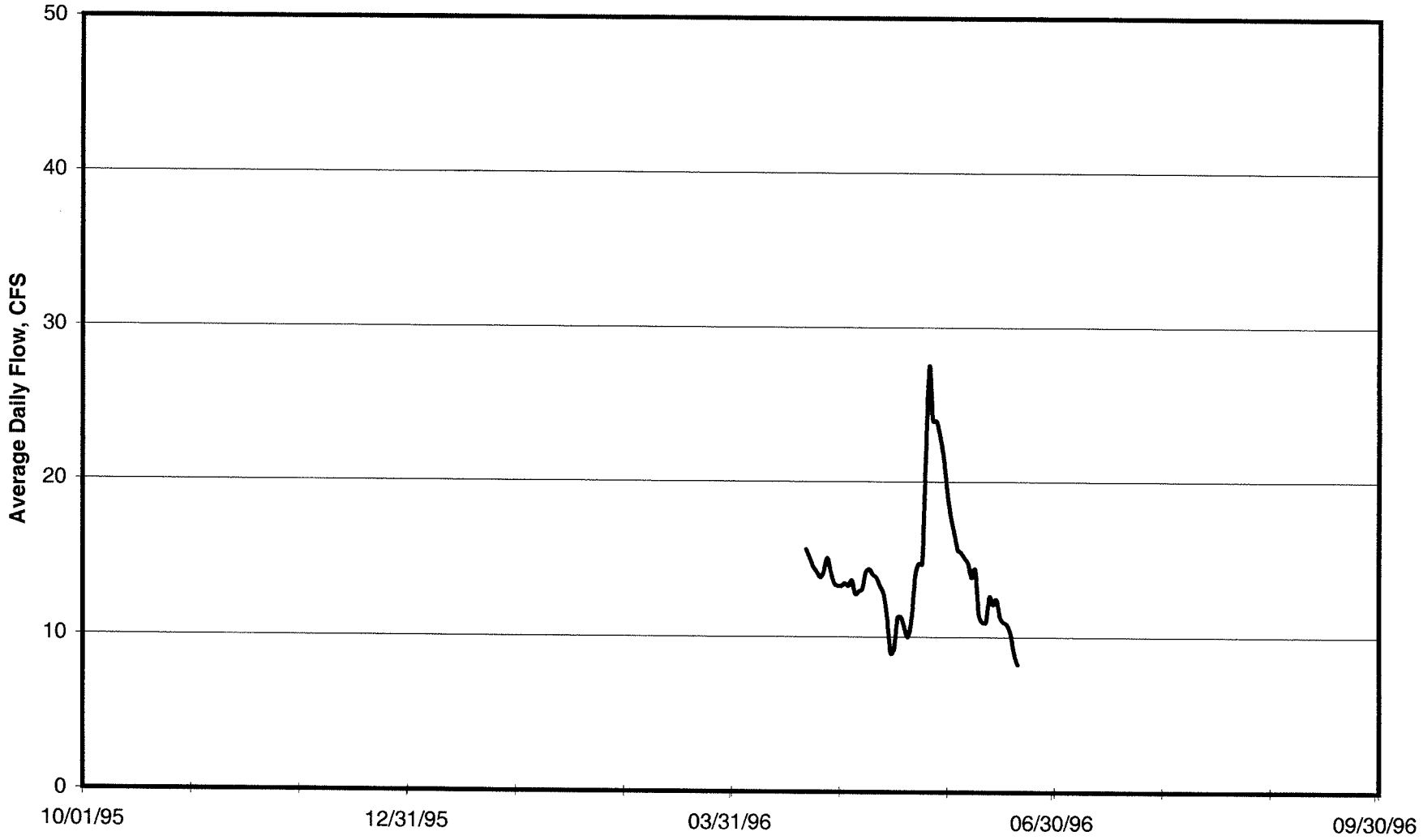
Niobrara River at Agate, Nebraska
February 1995 to June 2004



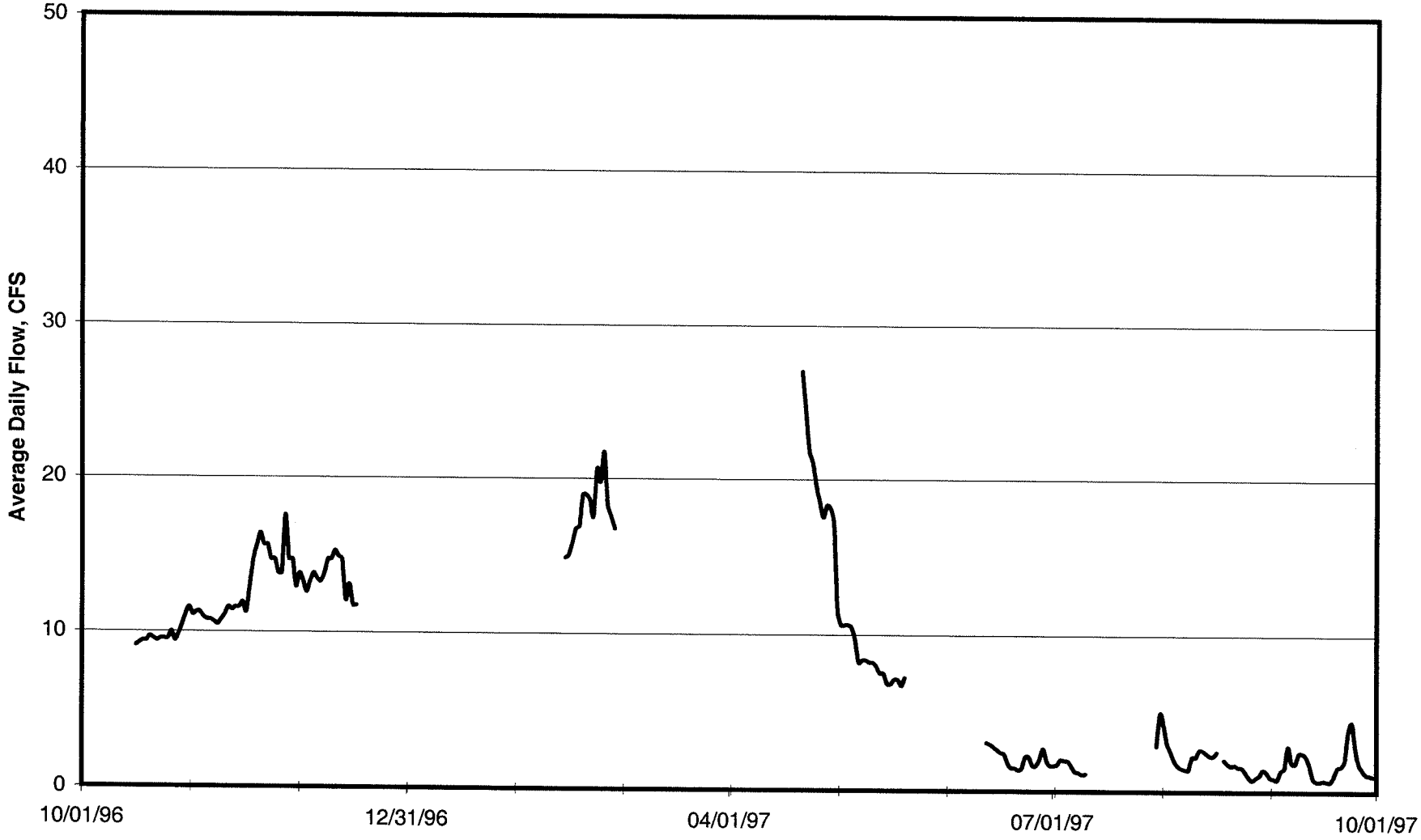
Niobrara River at Agate, Nebraska
October 1994 - September 1995



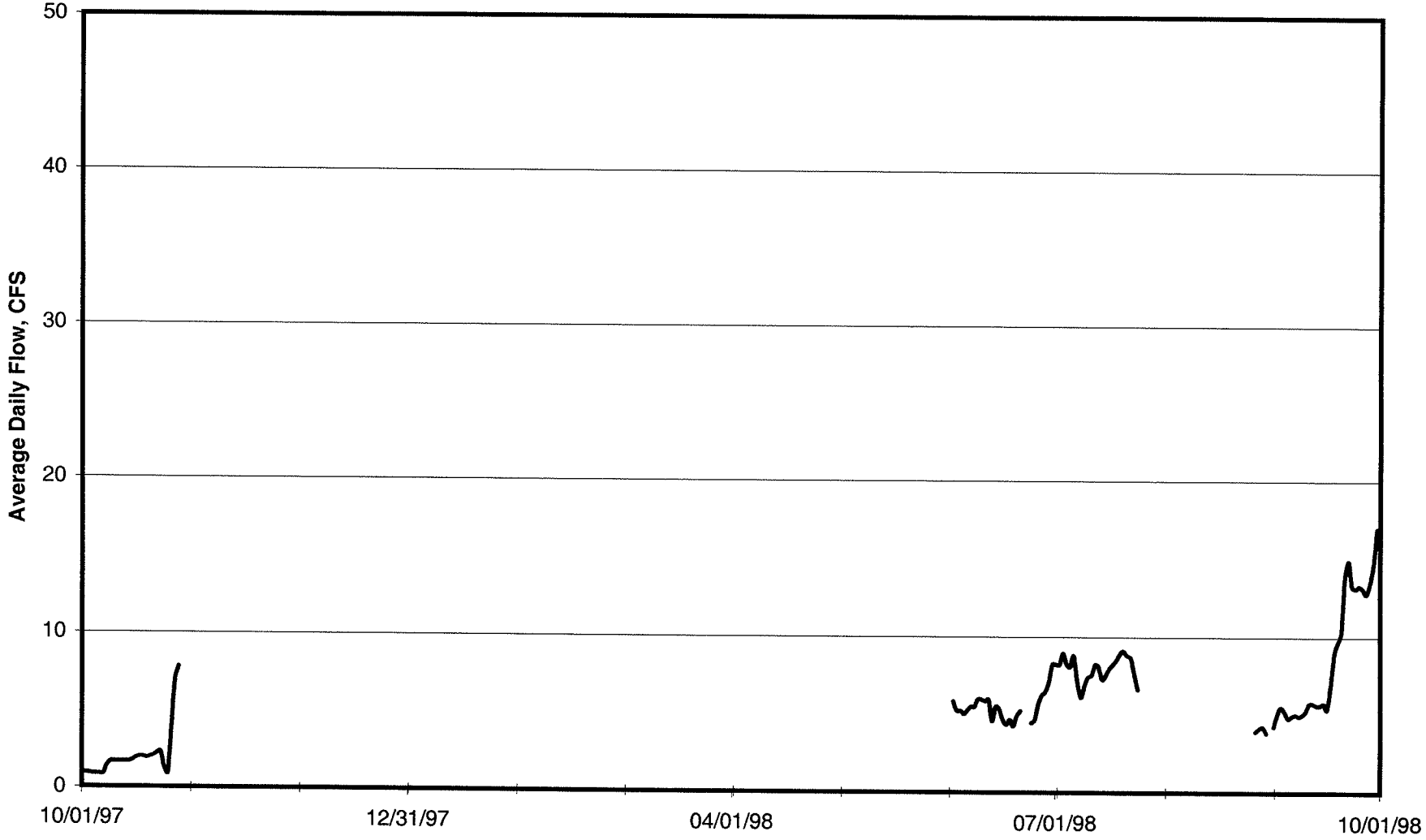
Niobrara River at Agate, Nebraska
October 1995 - September 1996



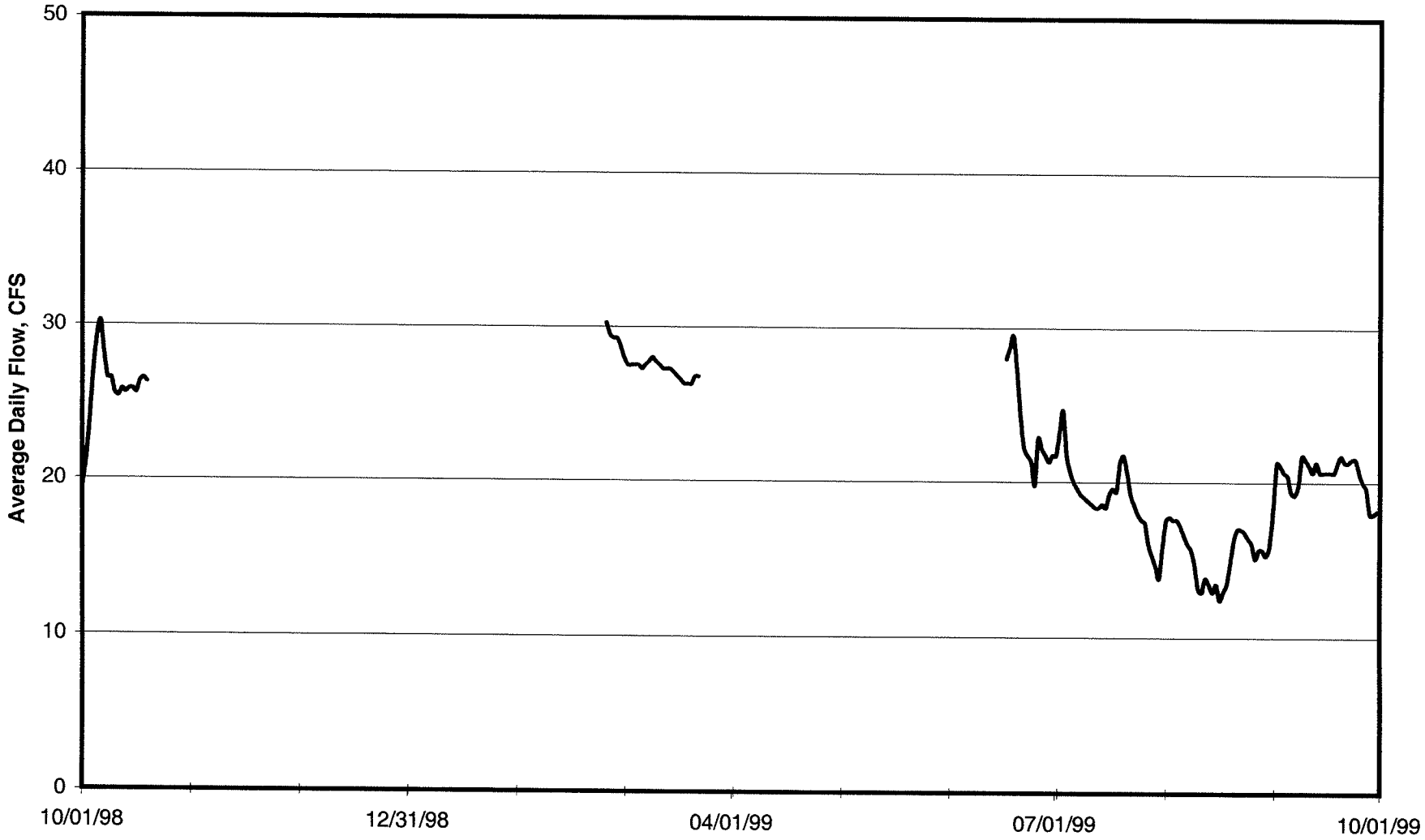
Niobrara River at Agate, Nebraska
October 1996 - September 1997



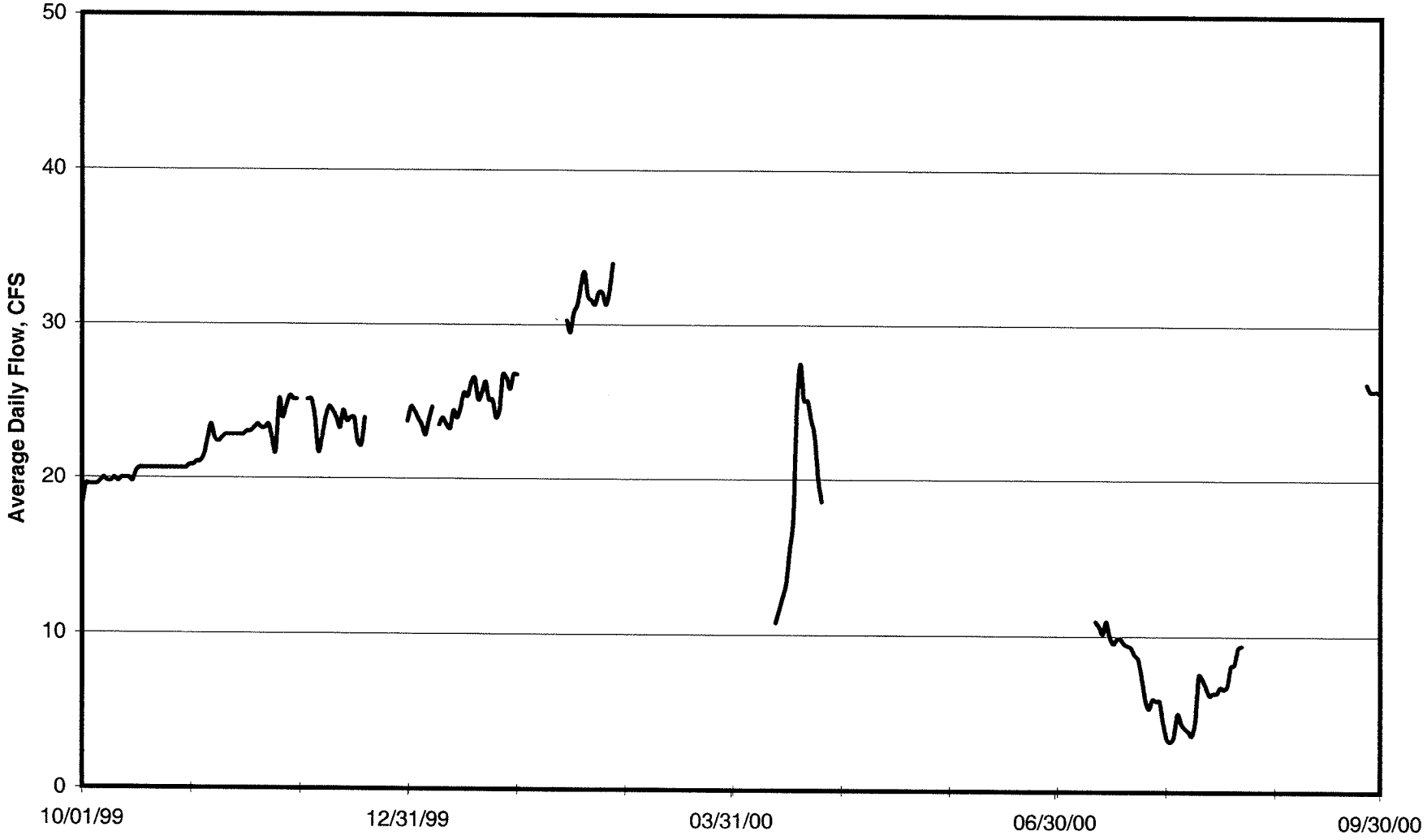
Niobrara River at Agate, Nebraska
October 1997 - September 1998



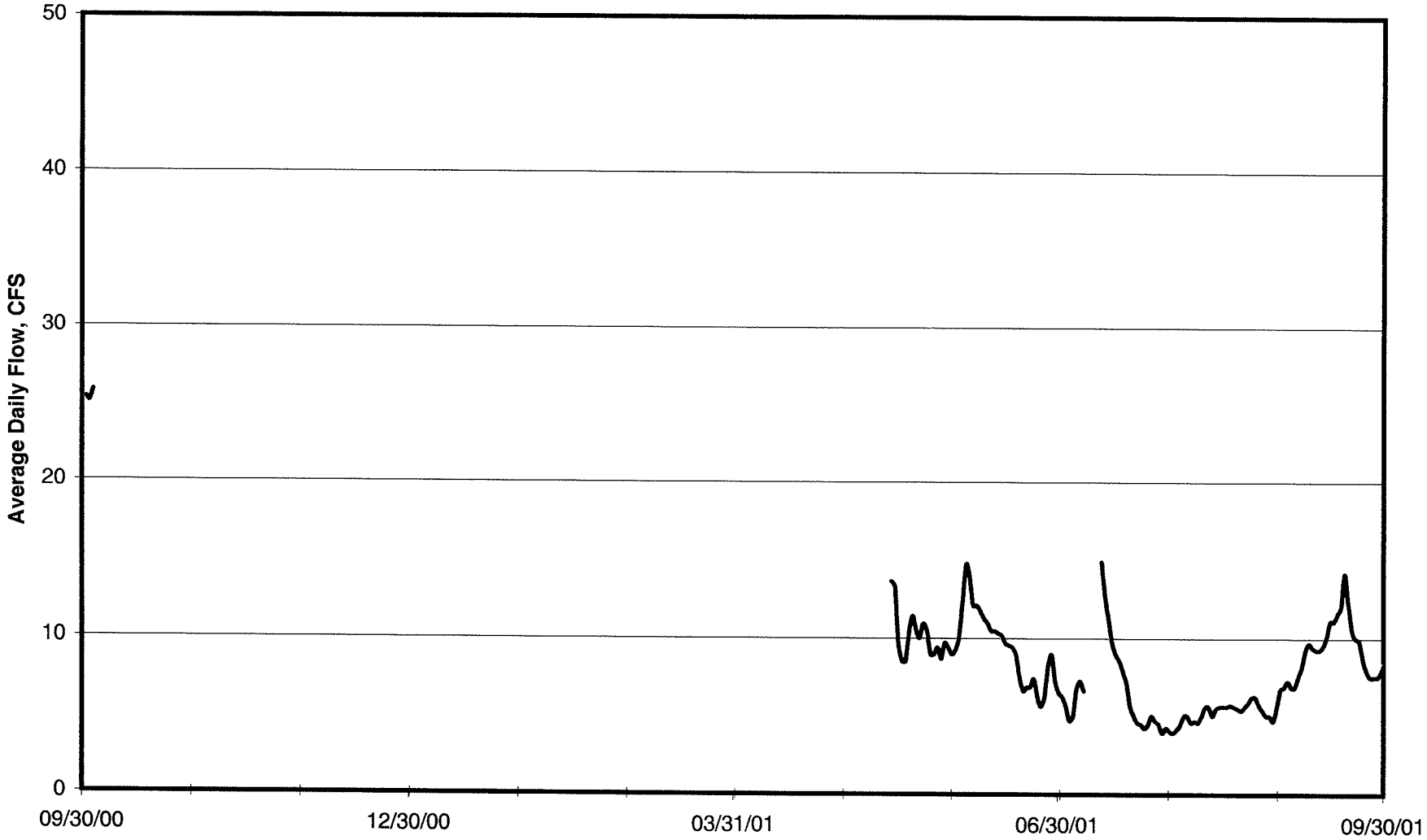
Niobrara River at Agate, Nebraska
October 1998 - September 1999



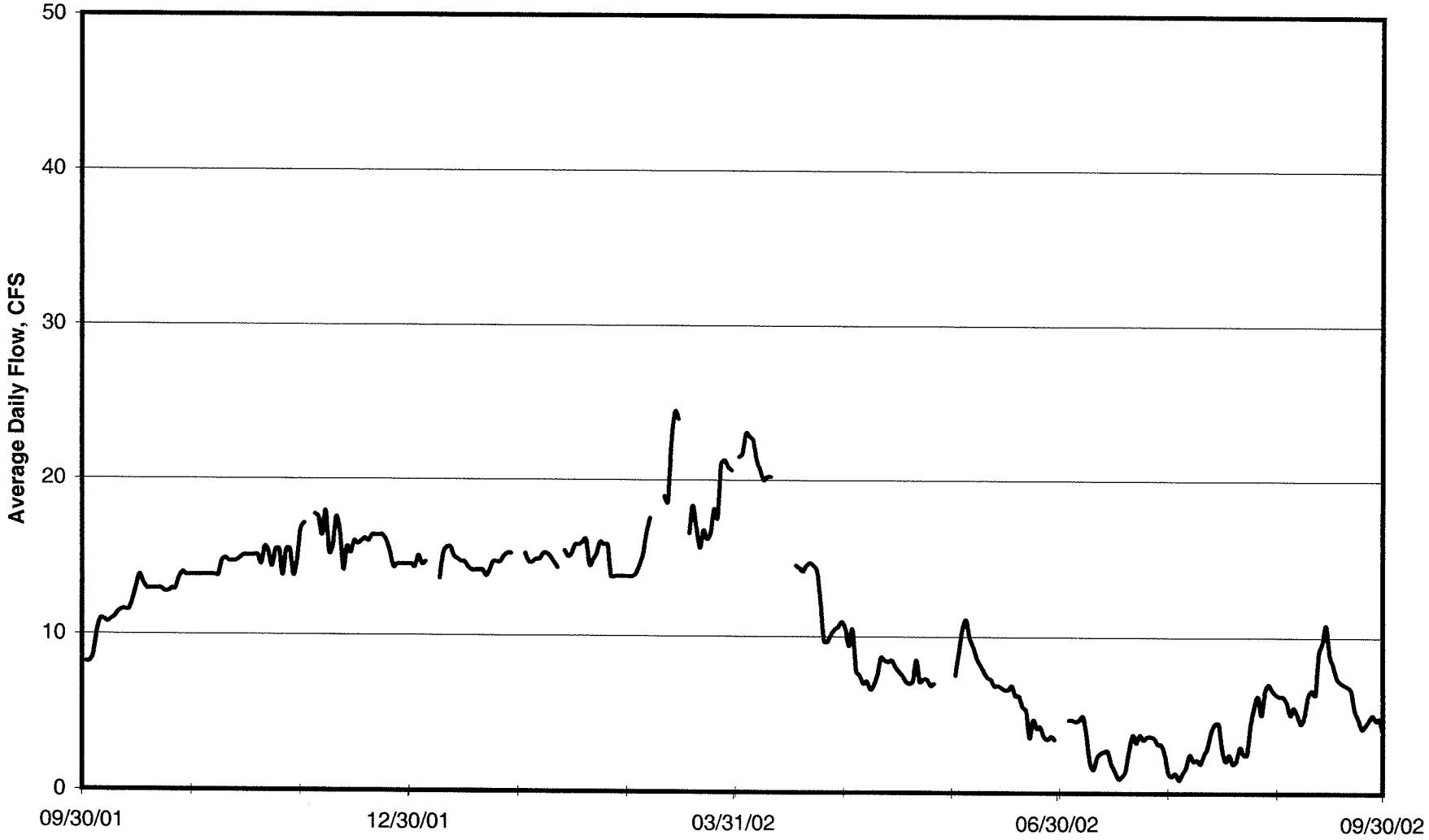
Niobrara River at Agate, Nebraska
October 1999 - September 2000



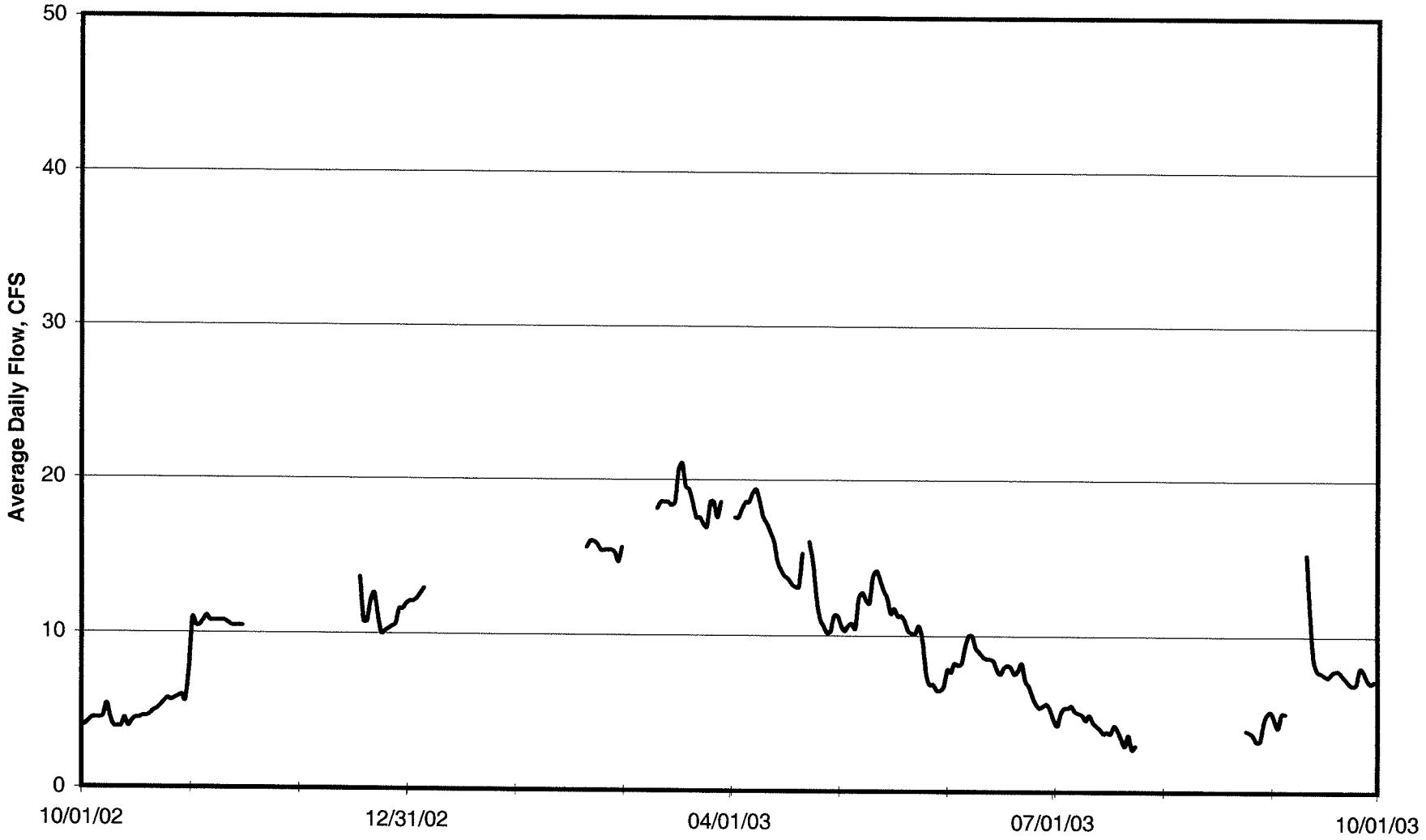
Niobrara River at Agate, Nebraska
October 2000 - September 2001



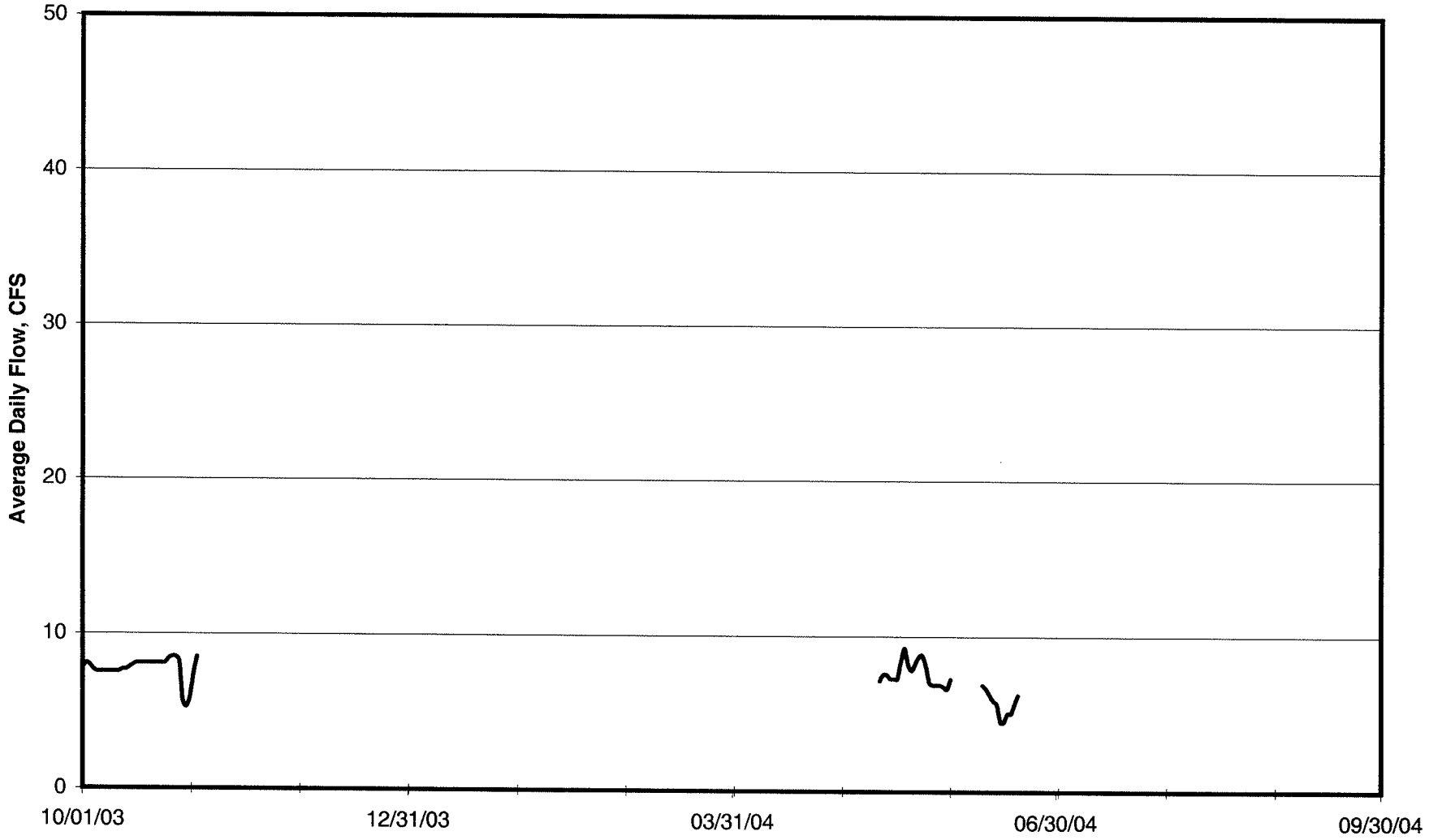
Niobrara River at Agate, Nebraska
October 2001 - September 2002



Niobrara River at Agate, Nebraska
October 2002 - September 2003



Niobrara River at Agate, Nebraska
October 2003 - September 2004



Data Tables

Niobrara River at Agate. Nebraska, Station 06454100

Discharge, Cubic Feet per Second, Water Year October 1994 through September 1995

Daily Mean Values

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1						18.2	13.4	8.7	25.4	11.6	8.1	9.7
2						18.2	13.1	8.4	22.8	11.3	8.2	
3						18.6	12.9	9.3	20.4	10.5	8.8	
4						18.2	12.6	8.8	21.7	10.8	9.4	
5						16.4	11.1	8.5	24.0	10.5	8.5	
6					20.4	19.0	10.6	9.4	24.4	9.7	8.2	
7					18.6	18.8	10.6	12.8	21.7	9.0	8.7	
8					18.0	18.6	11.4	20.6	20.2	9.3	9.3	
9					17.0	16.6	12.4	22.4	22.8	8.2	9.7	
10					14.7	16.2	11.8	20.0	28.8	8.5	9.7	
11					14.3	16.2	12.6	20.4	28.8	8.4	10.0	
12					14.3	17.4	12.9	21.7	25.6	8.5	10.5	
13					14.2	18.2	13.3	21.9	24.4	8.5	10.9	
14					14.2	18.0	12.6	20.9	23.1	8.4	11.3	
15					14.2	16.8	12.6	19.0	21.1	8.7	11.3	
16					12.9	15.8	13.3	18.6	20.2	8.5	11.3	
17					12.6	15.8	13.3	18.2	18.0	8.2	11.3	
18					13.8	16.0	13.3	17.4	16.8	8.2	9.0	
19					16.6	16.0	13.1	18.2	15.8	8.2	10.8	
20					19.2	16.0	13.1	21.1	15.1	8.5	10.9	
21					17.8	15.8	13.3	21.3	14.3	8.5	10.6	
22					18.2	15.4	13.1	18.6	14.0	8.1	10.5	
23					18.2	14.9	9.7	22.8	13.8	8.0	10.9	
24					18.6	14.7	8.5	24.7	13.6	8.1	10.9	
25					18.6	14.5	8.4	22.6	12.9	8.1	10.9	
26					18.2	13.8	8.2	24.0	12.2	8.1	10.5	
27					18.0	10.9	8.8	26.3	11.4	8.5	10.5	
28					18.2	10.5	8.1	29.3	12.9	8.7	10.5	
29						10.5	8.1	27.3	13.3	9.0	10.2	
30						13.8	8.7	26.1	12.8	9.4	10.3	
31						14.2				8.5	10.5	

Niobrara River at Agate. Nebraska, Station 06454100

Discharge, Cubic Feet per Second, Water Year October 1995 through September 1996

Daily Mean Values

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1												
2								13.3	19.6			
3								13.3	18.0			
4								13.4	16.8			
5								13.3	15.6			
6								13.6	15.4			
7								12.8	15.1			
8								12.9	14.7			
9								13.1	13.8			
10								14.2	14.3			
11								14.3	11.4			
12								14.0	10.9			
13								13.8	10.9			
14								13.3	12.6			
15								12.8	12.1			
16								11.3	12.4			
17								9.0	11.3			
18								9.3	10.9			
19								11.3	10.8			
20								11.3	10.2			
21								10.5	9.0			
22								10.0	8.2			
23							15.6	11.3				
24							15.1	14.0				
25							14.5	14.7				
26							14.2	14.7				
27							13.8	21.7				
28							14.2	27.5				
29							15.1	24.0				
30							14.2	24.0				
31							13.4	23.1				
								21.7				

Niobrara River at Agate. Nebraska, Station 06454100

Discharge, Cubic Feet per Second, Water Year October 1996 through September 1997

Daily Mean Values

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1		11.1	13.8					17.2		1.7	5.0	0.9
2		11.3	13.3					11.6		1.7	4.3	0.9
3		11.3	12.6					10.6		1.8	3.2	0.8
4		10.9	13.3					10.6		2.1	2.6	1.4
5		10.8	13.8					10.6		2.0	2.0	1.6
6		10.8	13.4					10.5		2.0	1.7	3.0
7		10.6	13.3					9.7		1.7	1.5	1.9
8		10.5	13.8					8.2		1.3	1.4	1.8
9		10.8	14.7					8.4		1.2	1.4	2.5
10		11.1	14.7					8.4		1.1	2.2	2.5
11		11.6	15.3					8.2		1.2	2.2	2.3
12		11.4	14.9					8.2			2.7	1.8
13		11.6	14.7					8.0	3.2		2.7	0.9
14		11.6	12.1		14.9			7.6	3.1		2.5	0.7
15		11.9	13.1		15.1			7.6	2.9		2.3	0.7
16	9.1	11.3	11.8		15.8			6.9	2.7		2.3	0.7
17	9.3	12.9	11.8		16.8			6.9	2.5		2.6	0.7
18	9.4	14.7			17.0			7.1	2.4			0.7
19	9.4	15.6			19.0			7.1	1.8		2.1	1.1
20	9.7	16.4			19.0			6.8	1.5		1.8	1.6
21	9.5	15.6			18.6			7.3	1.5		1.7	1.7
22	9.4	15.6			17.6		27.0		1.4		1.8	2.1
23	9.5	14.7			20.6		24.4		1.5		1.6	4.0
24	9.5	14.7			19.8		21.9		2.2		1.6	4.5
25	9.5	13.8			21.7		21.1		2.2		1.3	2.8
26	10.0	13.8			18.4		19.6		1.7		0.9	1.8
27	9.4	17.6			17.6		18.6		1.7		0.7	1.4
28	9.9	14.7			16.8		17.6		2.1		0.9	1.2
29	10.5	14.7					18.4		2.8		1.1	1.1
30	11.1	12.9					18.2		2.0		1.4	1.0
31	11.6									3.0	1.3	

Niobrara River at Agate. Nebraska, Station 06454100

Discharge, Cubic Feet per Second, Water Year October 1997 through September 1998

Daily Mean Values

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	1.0											
2	0.9									8.2		4.3
3	0.9									8.2		5.0
4	0.9								5.9	8.2		5.5
5	0.9								5.3	9.0		5.3
6	0.9								5.3	8.2		4.8
7	0.9								5.0	8.1		4.9
8	1.4								5.3	8.8		5.0
9	1.7								5.5	7.1		4.9
10	1.7								5.5	6.1		5.0
11	1.7								6.0	6.9		5.3
12	1.7								6.0	7.4		5.8
13	1.7								5.9	7.6		5.8
14	1.7								6.0	8.2		5.6
15	1.8								4.6	8.1		5.6
16	1.9								5.5	7.3		5.8
17	2.0								5.4	7.6		5.4
18	2.0								4.7	8.0		6.9
19	1.9								4.4	8.2		9.0
20	2.0								4.7	8.5		9.7
21	2.1								4.3	9.0		10.3
22	2.2								4.9	9.1		13.8
23	2.3								5.3	8.8		14.9
24	1.3									8.7		13.3
25	0.9									7.7		13.1
26	4.0								4.5	6.6		13.3
27	6.9								4.7			13.1
28	7.8								5.6		4.0	12.8
29									6.2		4.2	13.4
30									6.5		4.3	14.7
31									7.1		3.9	17.0

Niobrara River at Agate. Nebraska, Station 06454100

Discharge, Cubic Feet per Second, Water Year October 1998 through September 1999

Daily Mean Values

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	19.6					28.8				21.7	15.8	18.2
2	21.3					28.0				21.7	17.6	21.3
3	23.7					27.5				23.3	17.8	21.1
4	27.0					27.5				24.7	17.6	20.6
5	29.3					27.5				21.7	17.6	20.4
6	30.3					27.5				20.6	17.2	19.4
7	28.3					27.3				20.0	16.6	19.2
8	26.5					27.5				19.6	16.0	19.8
9	26.5					27.8				19.2	15.6	21.7
10	25.6					28.0				19.0	14.7	21.5
11	25.4					27.8				18.8	13.1	21.1
12	25.8					27.5				18.6	12.9	20.6
13	25.6					27.3				18.4	13.8	21.3
14	25.8					27.3				18.4	13.4	20.6
15	25.8					27.3				18.6	12.9	20.6
16	25.6					27.0				18.4	13.4	20.6
17	26.3					26.8				19.2	12.4	20.6
18	26.5					26.5			28.0	19.6	12.9	20.6
19	26.3					26.3			28.8	19.4	13.4	21.3
20						26.3			29.5	21.3	14.7	21.7
21						26.3			27.3	21.7	16.2	21.3
22						26.8			24.2	20.6	17.0	21.3
23						26.8			22.2	19.2	17.0	21.5
24									21.7	18.6	16.8	21.5
25					30.3				21.3	18.0	16.4	20.6
26					29.5				19.8	17.6	16.0	20.0
27					29.3				22.8	17.4	15.1	19.6
28					29.3				22.2	16.0	15.6	18.0
29									21.7	15.3	15.6	18.0
30									21.3	14.5	15.3	18.2
31										13.8	15.8	

Niobrara River at Agate. Nebraska, Station 06454100												
Discharge, Cubic Feet per Second, Water Year October 1999 through September 2000												
Daily Mean Values												
Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	18.4	20.9		24.7							3.4	
2	19.6	21.1		24.4							3.3	
3	19.6	21.1	25.1	24.0							3.5	
4	19.6	21.5	25.1	23.5							5.0	
5	19.6	22.6	24.0	22.8							4.5	
6	19.8	23.5	21.7	23.7							4.2	
7	20.0	22.6	22.6	24.7							4.0	
8	19.8	22.4	24.0								3.6	
9	19.8	22.6	24.7	23.5							4.5	
10	20.0	22.8	24.4	24.0							7.6	
11	19.8	22.8	24.0	23.5							7.3	
12	20.0	22.8	23.3	23.3						10.9	6.8	
13	20.0	22.8	24.4	24.4			10.8			10.6	6.2	
14	20.0	22.8	23.7	24.0	30.3		11.6			10.2	6.4	
15	19.8	22.8	24.0	24.7	29.5		12.4			10.9	6.4	
16	20.4	23.1	24.0	25.6	30.8		13.3			10.0	6.8	
17	20.6	23.1	22.4	25.4	31.3		15.4			9.5	6.6	
18	20.6	23.3	22.2	26.3	32.6		17.6			9.9	6.9	
19	20.6	23.5	24.0	26.5	33.4		25.1			9.9	8.1	
20	20.6	23.3		25.1	31.8		27.5			9.5	8.2	
21	20.6	23.3		25.6	31.6		25.1			9.4	9.3	
22	20.6	23.5		26.3	31.3		25.1			9.3	9.4	
23	20.6	22.6		25.1	32.1		24.0			8.8		
24	20.6	21.7		25.1	32.1		22.8			8.5		
25	20.6	25.1		24.0	31.3		20.0			7.3		
26	20.6	24.0		24.4	32.1		18.6			5.9		26.3
27	20.6	24.7		26.8	34.0					5.4		25.8
28	20.6	25.4		26.5						6.0		25.8
29	20.6	25.1		25.8						5.9		25.8
30	20.6	25.1		26.8						5.9		25.6
31	20.9		23.7	26.8						4.5		

Niobrara River at Agate. Nebraska, Station 06454100

Discharge, Cubic Feet per Second, Water Year October 2000 through September 2001

Daily Mean Values

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	25.4											
2	25.1								9.0	6.5	4.1	6.8
3	25.8								9.3	6.2	4.0	6.9
4									10.0	5.6	4.2	7.3
5									12.2	4.7	4.5	6.9
6									14.7	5.0	5.0	6.9
7									14.0	6.8	5.0	7.6
8									12.1	7.3	4.6	8.2
9									12.1	6.6	4.7	9.3
10									11.8		4.6	9.7
11									11.3		5.0	9.4
12									10.9		5.6	9.3
13									10.5		5.6	9.3
14									10.5	14.9	5.0	9.5
15									10.3	12.6	5.5	10.2
16								13.6	10.2	11.1	5.6	11.1
17								13.3	9.7	9.7	5.6	11.1
18								9.7	9.5	9.0	5.6	11.6
19								8.5	9.4	8.5	5.8	12.1
20								8.5	9.0	7.8	5.6	14.2
21								10.3	7.6	7.1	5.5	12.2
22								11.4	6.6	5.6	5.4	10.5
23								10.5	6.9	5.0	5.6	10.0
24								10.0	6.9	4.6	5.9	9.9
25								10.9	7.4	4.5	6.2	8.7
26								10.5	6.2	4.3	6.2	8.0
27								9.0	5.6	4.5	5.8	7.6
28								9.0	6.2	5.0	5.4	7.6
29								9.4	8.2	4.7	5.0	7.6
30								8.7	9.0	4.5	5.0	7.8
31								9.7	7.3	4.0	4.7	8.4
								9.4		4.3	5.6	

Niobrara River at Agate. Nebraska, Station 06454100												
Discharge, Cubic Feet per Second, Water Year October 2001 through September 2002												
Daily Mean Values												
Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	8.2	13.8	17.20	14.3	15.3	13.8		10.9			1.3	6.2
2	8.2	13.8		15.1	14.7	13.8	21.5	10.5	7.6		1.1	6.2
3	8.7	13.8		14.5	14.7	13.8	21.7	9.4	9.0		1.3	5.9
4	10.2	13.8	17.8	14.7	14.9	14.0	23.1	10.5	10.5	4.7	0.9	5.0
5	10.9	13.8	17.6		14.9	14.5	22.8	7.8	11.1	4.7	1.3	5.5
6	10.9	13.8	16.4		15.3	15.3	22.6	7.6	10.0	4.6	1.7	5.0
7	10.8	13.8	18.0		15.3	16.6	21.3	7.0	9.4	4.7	2.5	4.5
8	10.9	14.7	15.3	13.6	15.1	17.6	20.6	7.1	8.7	4.9	2.1	5.0
9	11.1	14.9	15.6	15.3	14.7		20.0	6.6	8.2	3.6	2.2	6.2
10	11.4	14.7	17.6	15.6	14.3		20.2	6.9	7.8	2.0	1.9	6.6
11	11.6	14.7	16.6	15.6			20.2	7.6	7.4	1.5	2.5	6.4
12	11.6	14.7	14.2	15.1	15.4	19.0		8.7	7.3	2.3	3.0	9.0
13	11.6	14.9	15.6	14.9	15.1	18.6		8.5	6.9	2.6	4.0	9.7
14	12.2	15.1	15.3	14.7	15.3	22.4		8.4	6.9	2.7	4.5	10.8
15	13.1	15.1	16.0	14.7	15.8	24.4		8.5	6.8	2.7	4.5	9.0
16	13.8	15.1	15.8	14.3	15.8	24.0		8.1	6.6	1.9	3.0	8.2
17	13.3	15.1	16.0	14.2	16.0			7.8	6.6	1.4	2.1	7.4
18	12.9	15.1	16.2	14.2	16.2		14.5	7.6	6.9	0.9	2.5	7.1
19	12.9	14.5	16.0	14.2	14.5	16.6	14.3	7.1	6.2	1.1	1.9	7.0
20	12.9	15.6	16.4	14.2	14.9	18.4	14.2	7.0	6.2	1.4	2.1	6.9
21	12.9	15.3	16.4	13.8	15.3	17.0	14.5	7.1	5.5	2.8	3.0	6.6
22	12.9	14.3	16.4	14.2	16.0	15.6	14.7	8.5	5.3	3.7	2.5	5.4
23	12.8	15.4	16.4	14.7	15.8	16.8	14.5	7.1	3.5	3.3	2.5	4.8
24	12.8	15.4	16.0	14.7	15.8	16.2	14.2	7.3	4.7	3.7	4.5	4.2
25	12.9	13.8	15.3	14.7	13.8	16.6	12.1	7.3	4.2	3.4	5.6	4.4
26	12.9	15.4	14.3	15.1	13.8	18.2	9.7	6.9	4.3	3.6	6.2	4.7
27	13.6	15.4	14.5	15.3	13.8	17.6	9.7	7.0	3.6	3.6	5.0	5.0
28	14.0	13.8	14.5	15.3	13.8	21.1	10.2		3.4	3.5	6.6	4.7
29	13.8	14.7	14.5			21.3	10.5		3.6	3.2	7.0	4.8
30	13.8	16.8	14.5			20.9	10.6		3.4	3.2	6.6	4.0
31	13.8		14.5			20.6				2.5	6.4	

Niobrara River at Agate. Nebraska, Station 06454100												
Discharge, Cubic Feet per Second, Water Year October 2002 through September 2003												
Daily Mean Values												
Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	4.0	10.9		12.1		14.7		11.3	6.8	5.3		5.2
2	4.1	10.5		12.1		15.6		11.3	7.8	4.6		4.6
3	4.3	10.5		12.2			17.6	10.6	7.7	4.3		4.2
4	4.5	10.8		12.6			17.6	10.3	8.2	5.0		5.0
5	4.5	11.1		12.9			18.2	10.6	8.1	5.4		5.0
6	4.5	10.8					18.6	10.8	8.2	5.4		
7	4.6	10.8					18.6	10.5	9.3	5.5		
8	5.4	10.8					19.2	12.4	10.0	5.2		
9	4.5	10.8					19.4	12.8	10.0	5.0		
10	4.0	10.8					18.6	12.2	9.3	4.9		
11	4.0	10.6					17.6	12.1	9.0	4.6		15.3
12	4.0	10.5				18.2	17.2	13.8	8.7	4.9		11.3
13	4.5	10.5				18.6	16.6	14.2	8.5	4.5		8.5
14	4.0	10.5			15.6	18.6	16.0	13.6	8.5	4.3		7.8
15	4.3	10.5			16.0	18.6	14.7	12.9	8.4	4.1		7.7
16	4.5				16.0	18.4	14.2	12.4	7.8	3.7		7.6
17	4.5				15.8	18.6	13.8	11.4	7.6	3.9		7.4
18	4.6		13.6		15.4	20.6	13.6	11.8	8.0	3.7		7.7
19	4.6		10.8		15.4	21.1	13.3	11.3	8.1	4.3		7.8
20	4.7		10.8		15.4	19.6	13.1	11.3	8.0	4.0		7.8
21	4.9		12.1		15.4	19.4	13.1	10.9	7.6	3.4		7.6
22	5.0		12.6		15.3	18.6	15.3	10.3	7.8	3.0		7.3
23	5.3		11.3			17.6		10.2	8.2	3.6		7.0
24	5.5		10.0			17.6	16.0	10.2	7.1	2.8		6.9
25	5.8		10.2			17.2	14.7	10.6	6.8	3.0	4.0	7.0
26	5.6		10.3			17.0	12.4	9.7	6.1		3.9	8.0
27	5.8		10.5			18.6	11.1	7.6	5.6		3.6	7.8
28	5.9		10.6			18.6	10.6	6.9	5.4		3.3	7.3
29	6.0		11.6			17.6	10.2	6.9	5.5		3.3	7.0
30	5.6		11.6			18.6	10.3	6.5	5.6		4.5	7.1
31	7.6		11.9					6.5			5.0	

Niobrara River at Agate. Nebraska, Station 06454100

Discharge, Cubic Feet per Second, Water Year October 2003 through September 2004

Daily Mean Values

Day	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	7.8	7.4										
2	8.1	8.5							7.30			
3	8.0											
4	7.7											
5	7.6											
6	7.6											
7	7.6											
8	7.6											
9	7.6											
10	7.6											
11	7.6								6.9			
12	7.7								6.6			
13	7.7							7.1	6.2			
14	7.8							7.6	5.9			
15	8.0							7.6	5.6			
16	8.1							7.3	4.5			
17	8.1							7.3	4.5			
18	8.1							7.3	5.0			
19	8.1							8.4	5.0			
20	8.1							9.3	5.6			
21	8.1							8.2	6.2			
22	8.1							7.8				
23	8.1							8.2				
24	8.1							8.7				
25	8.4							8.8				
26	8.5							8.1				
27	8.5							7.0				
28	8.2							6.9				
29	5.6							6.9				
30	5.3							6.9				
31	5.9							6.8				
								6.6				

Rating Table
and
Rating Curves

UNITED STATES DEPARTMENT OF INTERIOR - GEOLOGICAL SURVEY - WATER RESOURCES DIVISION

06454100
NIOBRARA RIVER AT AGATE, NEBR.
OFFSET: 2.00

EXPANDED RATING TABLE
DATE PROCESSED: 11-23-1994 @ 14:42 BY DEHITCH

TYPE: LOG

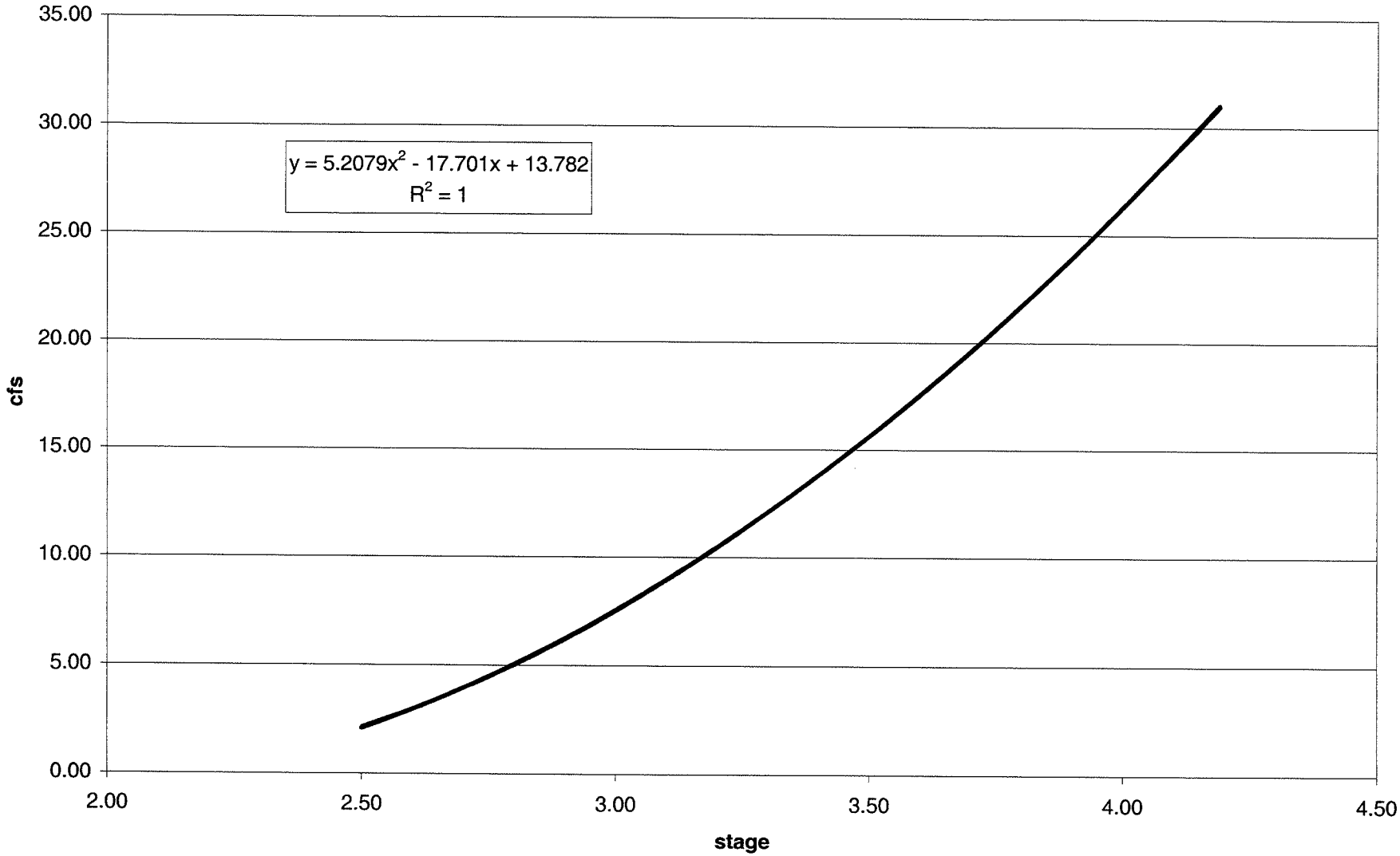
DD: 2 TYPE: 001 RATING NO: 8.00
START DATE/TIME: 10-01-86 (0015)

BASED ON _____ DISCHARGE MEASUREMENTS, NOS _____, AND _____, AND IS _____ WELL DEFINED BETWEEN _____ AND _____ CFS
COMP BY _____ DATE _____ CHK. BY _____ DATE _____

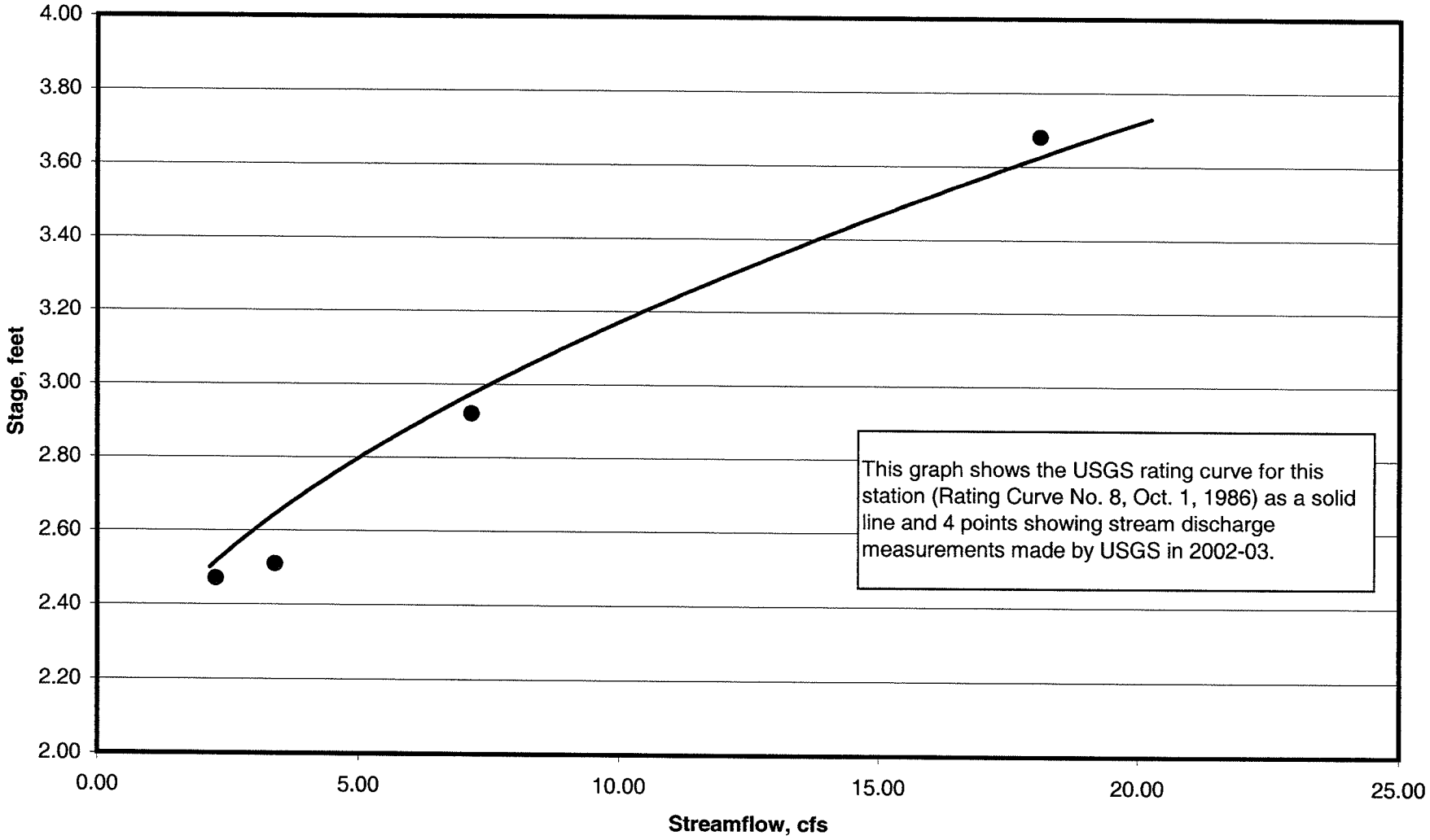
GAGE HEIGHT (FEET)	DISCHARGE IN CUBIC FEET PER SECOND (EXPANDED PRECISION)										DIFF IN Q PER TENTH FT
	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09	
2.50	2.150*	2.228	2.308	2.389	2.471	2.554	2.638	2.724	2.811	2.899	.839
2.60	2.989	3.079	3.171	3.264	3.358	3.454	3.550	3.648	3.747	3.847	.959
2.70	3.948	4.051	4.154	4.259	4.365	4.472	4.581	4.690	4.801	4.912	1.077
2.80	5.025	5.139	5.255	5.371	5.488	5.607	5.727	5.847	5.969	6.093	1.192
2.90	6.217	6.342	6.469	6.596	6.725	6.855	6.985	7.117	7.251	7.385	1.303
3.00	7.520	7.656	7.794	7.933	8.072	8.213	8.355	8.498	8.642	8.787	1.413
3.10	8.933	9.080	9.228	9.378	9.528	9.680	9.832	9.986	10.14	10.30	1.517
3.20	10.45	10.61	10.77	10.93	11.09	11.25	11.42	11.58	11.75	11.91	1.630
3.30	12.08	12.25	12.42	12.59	12.76	12.93	13.11	13.28	13.46	13.63	1.730
3.40	13.81	13.99	14.17	14.35	14.53	14.71	14.90	15.08	15.27	15.45	1.830
3.50	15.64	15.83	16.02	16.21	16.40	16.60	16.79	16.99	17.18	17.38	1.940
3.60	17.58	17.78	17.98	18.18	18.38	18.58	18.79	18.99	19.20	19.40	2.030
3.70	19.61	19.82	20.03	20.24	20.45	20.67	20.88	21.09	21.31	21.53	2.130
3.80	21.74	21.96	22.18	22.40	22.63	22.85	23.07	23.30	23.52	23.75	2.240
3.90	23.98	24.20	24.43	24.66	24.89	25.13	25.36	25.59	25.83	26.07	2.320
4.00	26.30	26.54	26.78	27.02	27.26	27.50	27.75	27.99	28.23	28.48	2.430
4.10	28.73	28.97	29.22	29.47	29.72	29.97	30.23	30.48	30.73	30.99	2.510
4.20	31.24	31.50	31.76	32.02	32.28	32.54	32.80	33.06	33.33	33.59	2.620
4.30	33.86	34.12	34.39	34.66	34.93	35.20	35.47	35.74	36.01	36.29	2.700
4.40	36.56	36.84	37.11	37.39	37.67	37.95	38.23	38.51	38.79	39.08	2.800
4.50	39.36	39.65	39.93	40.22	40.51	40.79	41.08	41.37	41.67	41.96	2.890
4.60	42.25	42.54	42.84	43.14	43.43	43.73	44.03	44.33	44.63	44.93	2.980
4.70	45.23	45.53	45.84	46.14	46.45	46.76	47.06	47.37	47.68	47.99	3.070
4.80	48.30	48.61	48.93	49.24	49.56	49.87	50.19	50.51	50.82	51.14	3.160
4.90	51.46	51.78	52.11	52.43	52.75	53.08	53.40	53.73	54.06	54.38	3.250
5.00	54.71	55.04	55.37	55.71	56.04	56.37	56.71	57.04	57.38	57.71	3.340
5.10	58.05	58.39	58.73	59.07	59.41	59.75	60.10	60.44	60.79	61.13	3.430
5.20	61.48	61.83	62.18	62.52	62.87	63.23	63.58	63.93	64.28	64.64	3.510
5.30	64.99	65.35	65.71	66.06	66.42	66.78	67.14	67.51	67.87	68.23	3.600
5.40	68.59	68.96	69.33	69.69	70.06	70.43	70.80	71.17	71.54	71.91	3.690
5.50	72.28	72.66	73.03	73.41	73.78	74.16	74.54	74.91	75.29	75.67	3.780
5.60	76.06	76.44	76.82	77.20	77.59	77.97	78.36	78.75	79.14	79.52	3.850
5.70	79.91	80.31	80.70	81.09	81.48	81.88	82.27	82.67	83.06	83.46	3.950
5.80	83.86	84.26	84.66	85.06	85.46	85.86	86.27	86.67	87.07	87.48	4.030
5.90	87.89	88.29	88.70	89.11	89.52	89.93	90.34	90.76	91.17	91.58	4.110*
6.00	92.00*										

11/28/94

Niobrara River at Agate Nebraska



Niobrara River at Agate, Nebraska
USGS Station 06454100



As the nation's principal conservation agency, the Department of the Interior has the responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The Department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.